

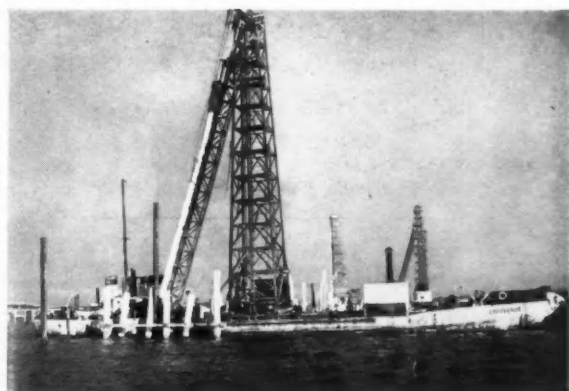
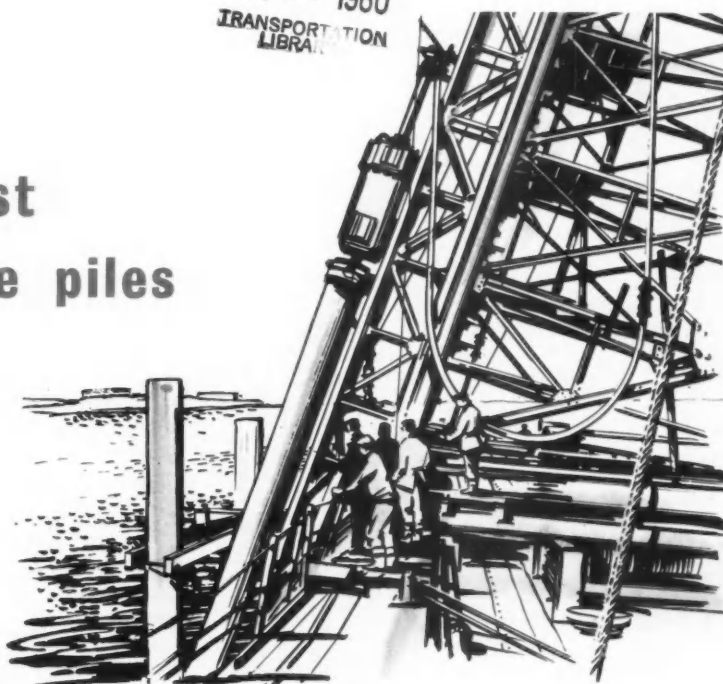
The Dock & Harbour Authority

No. 480 Vol. XLI

OCTOBER, 1960

Monthly 2s. 6d.

B.S.P. pile hammers drive Britain's longest pre-stressed concrete piles



m.v. "GROSVENOR" showing the pendulum leaders swivelled sideways and raked for driving.
Contractors: John Mowlem & Co. Ltd., London, S.W.1

Two special 95-ft. raking pile frames equipped with B.S.P. 8 ton and 10 ton single-acting hammers were used for driving vertical and raking cylindrical pre-stressed concrete bearing piles for the new Esso Marine Terminal at Milford Haven.

Mounted on the contractors' own vessels, each B.S.P. pile frame is designed to rake backwards to 1 in 3 and incorporates pendulum leaders capable of raking sideways independently to the same extent. The leaders may also be swivelled to face outwards or to either side as required.

The 27½-in. diameter 143-ft. long concrete bearing piles, the longest of this type to be installed in Gt. Britain, were driven in 60-ft. of water through 50-ft. of silt, sand and gravel to hard bedrock.



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Length (metres)	10	12	14	17	19	*Percentage of soil in mixture	10-20	10-20	10-20	10-20	10-20
Width (metres)	4	4,50	5	6	7	Soil production at max. height and distance cbm/h.	30-60	40-80	62-124	90-180	120-240
Depth (metres)	1,50	1,50	1,80	1,80	1,80	Diameter suction pipe (cm.)	20	25	30	35	40
Draft app. (metres)	0,65	0,70	0,80	0,80	0,75	Diameter discharge pipe (cm.)	17,5	20	25	30	35
Max. cutter depth (metres)	3,50	5	6	7	8	Total Diesel power H.P.	85	155	259	374	487
Max. distance of discharge (metres)	250	500	750	900	1000	* Note that the percentage of soil in the mixture depends on the nature of the soil and consequently the soil production will vary between the given figures.					
Max. height of discharge at max. distance (metres)	3	3	3	3	3						
Mixture production at max. height and distance cbm/h.	300	400	620	900	1200						

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The Dock & Harbour Authority

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No. 480

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Editorial Notes

New Passenger Facilities at Sydney

The description of the new passenger terminal at Sydney which we publish in this issue will be studied with great interest. In the provision of modern amenities, proper separation of passengers and their baggage from cargo operations (when the berth must serve a dual role) and good traffic circulation are, of course, necessities. To bring passenger traffic to the centre of a city through the front door, in interesting and agreeable surroundings, is a convenience which air transport cannot offer. It is a matter for remark that sea transport seldom seems able to exploit an inherent advantage. Aided by unrivalled physical attractions and by good civic planning, the Maritime Board of New South Wales and the City authorities have now made Sydney a refreshing exception to a too general rule.

To engineers, the chief interest in the project will lie in the design of the substructure which consists of caissons constructed in the dry and floated out for sinking on to a prepared bed. Examples of the same or similar forms of construction are to be found at Marseilles, Naples and other European ports, at Dublin (though here supplementary piling through the floor of the caissons has been provided), and in Japan. But we believe that it was at Rotterdam that the system was first employed successfully, later being adopted extensively throughout other ports of the Netherlands.

In the western part of that country, in the alluvial formation composing the estuarial lands of two great rivers, the subsoil consists of clay and silt to a considerable depth below cultivated ground level but, below this, at depths ranging to 30 and 40-ft., is to be found a deep stratum of sand sometimes mixed with gravel. It is upon this foundation that the deepwater quays of Rotterdam have been built. The construction in ground of this character has been achieved by first dredging away the inferior material overlying the substratum of sand and replacing by deposition in the deep areas so dredged a firm base of coarse sand or ballast upon which, after levelling, closed caissons are founded. The initial step, therefore, has been the improvement of the ground by artificial means. With this method an accurate foreknowledge of the properties of the sand filling for the reclamation behind the wall is essential and the technique is best employed where there is only a moderate tidal range. At Rotterdam the design criteria adopted for such structures and with such materials are that the inclination of the resultant of all forces shall not exceed 30° from the vertical, and it must pass through the middle third of the base with a foundation pressure not more than 3½-4 tons per square foot. The intention at Sydney seems to have followed this pattern and the paper serves a useful purpose in re-focussing attention on a type of construction which, in suitable circumstances, might often be used in preference to other methods currently in vogue.

As a matter of interest, the design work at Sydney appears to have been "frozen" at an early stage before a decision was reached about the subsequent filling of the reclamation and it might be argued that with the superior material ultimately forthcoming a more orthodox form of wharf construction would have been less costly. Even if this were true, it would be carping criticism. Every design should reflect its environment and it is doubly beneficial if the by-products of one project can be embodied in another. But the difficulties of co-ordinating the programmes of totally dissimilar undertakings to this end are great indeed. The details of the caisson design and of the launching arrangements which the paper describes recall to mind another occasion seventeen years ago when Phoenix units of a certain type were being constructed in a similar manner for the Mulberry Harbour project at Arromanches, France, in the Second World War. The launching weight of these was three or four times that of the Sydney caissons and some of them were hauled a quarter of a mile to the head of the launching ways. No doubt they might have served in a similar permanent role had there been facilities for preparing a bed for them on the other side of the Channel.

Liability for Damaged Cargo

We publish in our correspondence columns this month a letter which raises a subject of considerable importance. The problem of dealing with claims for damaged cargo is to ascertain where the damage occurred and to place the responsibility fairly and squarely where it belongs. It is axiomatic that the fewer *handlings* there are, the less the likelihood of breakage but from the standpoint of assigning responsibility there should be as few changes of *custody* as possible, and these should take place where there is reasonable opportunity for scrutiny without delaying the overall transfer.

In the traditional practice of terminal working where the ocean carrier accepts no responsibility beyond the confines of the ship and a third party is interposed between carrier and cargo owner these conditions are not fully met. The shipper (or consignee) will ordinarily wish to retain the carrier who gives the best out-turn of his goods but he cannot, as a rule, pick and choose the wharfinger. A situation in which good work in one direction can be nullified by indifference in another, whilst obscuring the true responsibility, can lead only to a debasement of standards. Nobody gains by this. Ultimately the manufacturer is the loser because the purchaser is discouraged from repeating his order when the price becomes loaded with everybody's breakages.

Many manufacturers, of course, are alive to the danger. They take infinite pains to trace through every stage in the movement of their consignments and to devise with their packaging experts

Editorial Notes—continued

the most suitable protection which will minimise damage without unduly enhancing freight. For there comes a point where costly packaging, subjected not only to use but to abuse, begins to defeat its own object. Often the bare commodity, which can be seen for what it is, commands the greater respect but it is not always appreciated what may constitute material damage. Exemption clauses in a Bill of Lading or other contract of carriage are not of themselves harmful provided that the carrier by land or water is brought to a sense of personal responsibility by the knowledge that unless he treats cargo with proper consideration he may lose the custom.

This surely is the only way to better performance, a thought which was uppermost in our mind when we observed in these columns last month that a marine terminal was a "point of interchange between inland and ocean carriers." The subject at issue now is only one aspect (though an important one) of a general argument which has received considerable attention in this Journal during the past twelve months and which, perhaps, that phrase might serve to epitomise.

The Port of Mwanza—Lake Victoria

Studies in inland transport do not generally come within the purview of this Journal. The new terminal constructed at Mwanza on Lake Victoria which is described in this issue is essentially an integral part of a system of land communications where railways play the dominant role. Neither is Mwanza to be described as a port in the sense in which we are accustomed to employ the term. Lake Victoria, however, is the third largest lake in the world; if we exclude the Caspian Sea (whose status as a lake is rather belied by its name), only Lake Superior exceeds it in area, and that by only a small margin. It provides the most convenient means (and perhaps the only means) of gathering produce and distributing merchandise over large and potentially rich areas and so assisting their development.

Most of this traffic in the contiguous territories of Kenya, Uganda and Tanganyika must be channelled through the railway system of the East African Railways and Harbours Administration and its major ocean ports of Mombasa (Kilindini) and Dar es Salaam. The Kenya and Uganda section of the line (disregarding the many branch services) follows the route Nairobi, Kampala, Kasese—near the Congo border—with a link to Port Bell on Lake Victoria from which lake services are maintained with Entebbe, Kisumu and the Tanganyika terminals at Bukoba and Mwanza. The Tanganyika section of the railway proceeds from Dar es Salaam to Tabora from whence one route goes to Kigome on Lake Tanganyika and another northwards to Mwanza. Including branch lines, the Administration provides some 3,400 route miles of rail services throughout the extent of the Crown Colony, Protectorates and Trust Territory, and doubtless some road services too and, surprisingly, as much as 6,000 route miles of steamship services on the various Central African lakes and on the Nile River. The whole constitutes a remarkable example of a single integrated system of surface transport serving the territories, each of which has its own form of government, its special economic and social problems and each of which is advancing towards self-determination and political independence.

At a time when much public attention is being drawn towards political events and controversy in these lands, it is not always appreciated that a unified transport organisation and valuable economic co-ordination conferring great benefit on all has hitherto been achieved by a form of federal government operating in these fields. The East African High Commission constituted by an Order of Council in 1947 administers many inter-territorial services and with the advice and consent of the East African Central Legislative Assembly established by the same Order in Council has had the power to legislate in many matters of com-

mon interest to the constituent authorities, such as Railways, Harbours and Inland Waterways, Civil Aviation, Customs and Excise, Posts and Telegraphs and the like. It is idle to pretend that subjects of this order can be elevated to a non-controversial plane, but the experience and agreement gained by working together in a common task must be of the greatest value if and when the separate territories have to rely upon an independent judgment in their own counsels. This is assuredly a pattern which ought to be preserved, at almost any cost.

Nigerian Port Development

In view of the increasing importance of the port industry to her economy, it is fitting that the ceremonies held earlier this month to mark the inception of Nigeria as an independent member of the British Commonwealth should include celebrations inaugurating the opening of the wharf extensions at Port Harcourt.

These improvements, estimated to cost a total of £4 million, are being constructed for the Nigerian Ports Authority to the design of Coode and Partners, consulting engineers, London, by Taylor Woodrow (Nigeria) Ltd., of Lagos and London, and are now nearly complete. They will more than double the port's handling capacity and include 1,600-ft. of wharf wall, giving three extra berths; three large transit sheds; a warehouse and a dock office block, Customs House, mechanical workshops and storage and ancillary buildings.

Rapid movement by road and rail of inward and outward bound cargoes is an essential feature of the plan and other works are a road system and a railway marshalling yard—a major part of which is constructed on a six-acre area of reclaimed swamp.

Port Harcourt is situated about 27 miles from the sea on the Bonny River, which winds through mangrove swamps and the creeks of the Niger delta where the annual rainfall averages more than 100 inches. The first deep water wharves were built in 1923 when two berths were constructed; a further two berths were built in 1927. The line of the new wharf runs southwards from the original wharf and has required the removal of a promontory projecting into the river.

As each phase of the present contract has been completed it has been handed over and used immediately, so as to facilitate the faster turn-round of shipping which has become necessary in view of the growing volume of trade, which last year exceeded one million tons and is now being increased by oil exports, which at present total 16,500 barrels a day and are rising steadily.

This impetus and encouragement given by the oil industry has played a significant part in the growth of industry in Port Harcourt. Management and supervisory activities are being centred there and a new industrial and administrative headquarters is being set up. Oil was first found at Oloibiri (45 miles west of Port Harcourt) in January 1956 and, following two years development work which included the laying of a 60 mile pipeline (at a cost of over £1 million) from the oilfield to the port, the first tanker left Port Harcourt for a Netherlands refinery in February 1958. In the same year further pipelines were laid connecting the port with oilfields at Afam and Bomu.

It is of interest to note that the number of ships and the tonnages of cargo handled by the Nigerian Ports Authority at the Apapa and Customs Quays, Lagos and at Port Harcourt during the year ended 31st March, 1960, were the highest yet recorded. A total of 2,393,553 tons of cargo was handled over the quays—an increase of 90,165 tons, or 3.9 per cent over the previous year's figure. The gross income of the Authority rose by £281,574 to a new record of £5,660,236. After charging depreciation, interest on and amortisation of loans etc., the trading profit for the year was £739,537.

We propose to publish a full description of the new construction works at Port Harcourt in our November issue.

The West Sydney Cove Passenger Terminal

Description of New Facility for Super Liners

by J. A. STUART, M.I.E.Aust., M.Inst.T.,
(Deputy Engineer-in-Chief Maritime Services Board of New South Wales)

The Site

The decisions of the P. and O. and Orient Companies that each would build a super liner for the Australia run heralded a new era in passenger travel to this continent and faced the Maritime Services Board of N.S.W. with a serious problem in accommodation. The existing passenger berths in the Port of Sydney comprise Nos. 19, 20 and 21 berths, Pyrmont, built some 43 years ago, used by the P. and O. Company and completely inadequate for modern passenger travel; Nos. 12 and 13 berths, Pyrmont, built some 20 years ago, used by the Orient Company and, although suitable for the 28,000 tonners of that line, completely inadequate for either "Oriana" or "Canberra"; No. 7 berth, Woolloomooloo, an old structure similar to 19-21 Pyrmont, converted in the post-war period for passenger use by the Matson line.

Vehicular traffic leaving the Pyrmont area has to cross Pyrmont Bridge in order to reach the city and Glebe Island Bridge for direct access to the north-western suburbs. Both bridges have opening spans and the post-war growth of road traffic has led to serious congestion at sailing times and to considerable public criticism. Pyrmont, therefore, was not considered a suitable site. Moreover, as the new liners will so greatly exceed in size and passenger complement all ships regularly engaged on the run, construction of a new berth was required rather than conversion of an existing berth.

For many years past, the Board has envisaged construction of a passenger terminal at West Sydney Cove in the form of twin berths each capable of accommodating a passenger liner of pre-war standard. It is now considered fortunate that the war prevented the plans from being implemented. Sydney Cove, richly endowed with its history of early settlement and colonial days, is the front doorway to the City of Sydney and it is appropriate that visitors from overseas should enter there rather than through areas occupied by waterfront industries.

The Substructure

The site of the terminal is backed by the Port roadway which starts in Sydney Cove at the Board's head office and skirts the foreshore of the harbour, serving the wharfage systems of Walsh Bay, Darling Harbour and Pyrmont. The size of the new structure made it necessary to establish the fender line some 100-ft. beyond that of the existing wharf and approximately 150-ft. beyond the old sea wall. An investigation of various alternatives showed that the cheapest and quickest method of constructing the substructure would be by solid fill reclamation behind a sea-wall of reinforced concrete caissons.

It was intended that sand dredged from the harbour should be used to provide the 150,000 cubic yards of filling required and an extensive survey was made to locate suitable deposits. The physical properties of the sand influenced the design of the caissons and had to be established early. Most of the sand within reasonable distance of the site is heavily impregnated with silt and required suction dredging for its recovery. A bank of clean sand with a relatively high shell content and 95 lbs per cubic ft. density was located between the two main channels leading into

the Port. It was decided to recover this material by a grab dredge loading into 650-ton hopper barges which would be towed behind the caisson wall prior to discharging. Although the hydraulically operated doors of the first barge were opened with considerable care, the sand spread several hundred feet and blanketed the bed prepared to receive the last few caissons. With the problem of discharge still unsolved, large quantities of sandstone ballast became available from city construction projects and this material was used for the whole of the reclamation in place of sand and at a fraction of the estimated cost of the sand.

The caisson wall consists of 14 caissons each 50-ft. long surmounted by a reinforced concrete sea wall 7-ft. high. The overall length of the wall is 720-ft. At the northern end, the fill is retained by a transverse wall of Larssen-type piling which links the old sea wall with the new. To the south, a new sea wall which is nearing completion will extend in a graceful curve from the southern end of the terminal to the promenade which traverses the ferry entrances from east to west across Circular Quay. The northern section of this wall adjoining the terminal is of steel piling and sufficient depth of water will be available for the Commissioners' launches to berth at landing steps directly in front of the head office building. The central section will consist of precast concrete units on a cast in-situ base and surmounted by an in-situ top. The southern section adjoining the Quay promenade will be piled where it bridges the outlet of the Tank Stream—the source of fresh water supplies for the early settlers and now a storm-water channel for part of the City. The promenade behind this sea wall will be landscaped in a manner in keeping with the structure to which it will lead.

The footings for the structural steelwork of the superstructure of the terminal are at 25-ft. centres in each of 3 rows 625-ft. long. The landward row is located at or near the old sea wall and consists of 1 metre Benoto piers constructed prior to the placing of fill in the reclamation. The central and outer rows are of steel piles driven in clusters. The section used was an under-run 10-in. x 8-in. R.S.J. which approximates to a 9-in. x 9-in. x 95 lbs. section. These were driven through the ballast fill to refusal in rock by means of a 20-ton Coles crane with an 80-ft. jib and leaders carrying a 9B3 double acting hammer.

The maximum design loading was 70 tons per pile. The pile lengths ranged to 76-ft. and, when single lengths were not available, sections were spliced by Thermit welding. The only preparation consisted of splaying back the flanges at the toe by flame cutting and blowing a hole in the web near the head for handling. This proved to be an excellent type of pile which, it is expected, will be used extensively for similar work in this Port. Prior to supplies becoming available, boxed Larssen-type piles were used to a limited extent.

The Superstructure

Behind the 40-ft. apron of the new terminal, the superstructure extends 625-ft. in a north-south direction with a width of 111-ft. The architectural treatment of the superstructure is modern in character, but it is not contemporary to a degree that might

Sydney Passenger Terminal—continued

offend conservative taste. The flat monotonous lines that could have emerged from a purely functional treatment have been avoided by provision of a tower which separates the Customs examination hall from the waiting hall. Glass and aluminium are being used extensively to bring light and air into the structure and increase the outward visibility. The conventional pitched roof has given way to a wing-shaped covering of aluminium supported on structural steel frames cantilevering out



In December 1958, the first caisson was placed in position not far from the Board's Head Office building.

over the walkways and promenade galleries. So far as practicable, the colour used will be in permanent form such as exposed aggregate and glass mosaics.

The western wall fronting the Port roadway is being built of concrete block walling up to window level. Elsewhere, the walling is mainly of pre-cast concrete panels faced with exposed aggregate of pink granite. On the southern elevation facing the City, glass mosaics will be used extensively.

At ground level, the section south of the tower includes the main entrance with escalator and stairs leading to the waiting hall on the upper floor, special cargo store rooms and toilet facilities for port workers. The tower section will house a change room and toilet facilities for Customs personnel, in part at ground level and also at mezzanine level. The remainder of the ground floor area will be occupied mainly by the cargo shed traversed on the western side by an internal roadway with doorways at the northern and southern ends of the terminal. Access to the wharf apron will be through 12 motorised roller shutter doors each 17-ft. wide. Three mechanical conveyors will raise baggage from the wharf apron to the upper floor for Customs examination.

At upper floor level, the waiting hall is located south of the tower. A snack bar and various tourist facilities will be provided. The Customs examination hall occupies all of this floor to the north of the tower and is connected to the waiting hall by an entrance vestibule. The three conveyors from the lower deck will discharge baggage at points spaced along the length of the hall from which it will be passed to the tables for declaration. The main toilet facilities are on a floor above the entrance vestibule. Amenities for waterside workers including a change room, lunch room, snack bar and shop, toilets, washroom and showers are housed in the northern end of the building at ground and mezzanine floor levels.

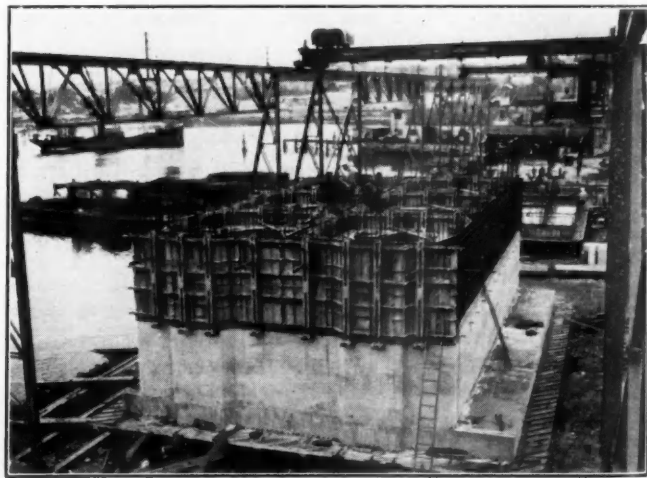
The first floor is the level at which passengers will join or leave the ship. This floor is flanked on its western side by a high level 3-lane external roadway 32-ft. wide connected to

Hickson Road at the northern end and George Street North at the southern end by means of two reinforced concrete bridges each virtually identical and having a 6-ft. footway and a 32-ft. carriageway. Each bridge is of two spans with nine 80-ft. prestressed reinforced concrete girders in each span and carries a cast-in-situ deck. Passengers arriving on the upper deck by car will alight at the 600-ft. footway along the upper roadway and enter by the vestibule at the tower. The tower has provision for office accommodation on its upper floors which will be served by a lift operating from the lower mezzanine floor.

A passengers' gallery has been provided along the full length of the upper floor and around part of the northern elevation. Above this gallery, a visitors' balcony has been provided. This extends from the tower to the northern end of the building and it also returns around the northern end where a concentration of viewers can be expected at arrivals and departures. This balcony is connected by lift and stairway to the entrance vestibule and by stairway to outside access at the northern end. Otherwise it is isolated from the passenger gallery and Customs examination hall.

The structural steel frame work and the suspended concrete floor system of the superstructure are divided into three independent sections by two transverse expansion joints. The steelwork, aggregating some 1,000 tons, was supplied and erected under contract. Late completion of this part of the work has seriously delayed subsequent operations and advanced the completion date for the terminal from June, 1960, to December, 1960.

Five passenger gantries each with a telescopic aluminium gangway of stressed-skin construction will connect the passenger gallery to the ship. Each gantry will have a travel speed of 50-ft. per minute with hydraulic drive from an 8 H.P. motor operating on 110 volts D.C. fed from collector wires on the side of the building. The operations of elevating and extending or retracting the gangways will be by hydraulic power. Adequate provision



The first stage of caisson construction was carried out on launching platforms served by two 5-ton overhead cranes.

has been made for rise and fall of the ship and for ranging when the gangways are supported on the side of the ship. When not in use, the retracted gangways will be lowered and stowed clear of the shipping clearance line.

Fendering

The fendering system consists of timber grids 25-ft. long carrying Andre rubber fender units type F.A.R. 5539/2 spaced in pairs at 8-ft. 6-in. centres along the berth with an energy absorption value of 1.4-ft. tons per foot of berth. The system has been

Sydney Passenger Terminal—continued

designed for a ship of 45,000 tons displacement moving at 0.5-ft. per second normal to the berth with kinetic energy 175-ft. tons of which one half is to be absorbed by the fendering system. This 87.5-ft. tons would be absorbed in 62.5-ft. of berth.

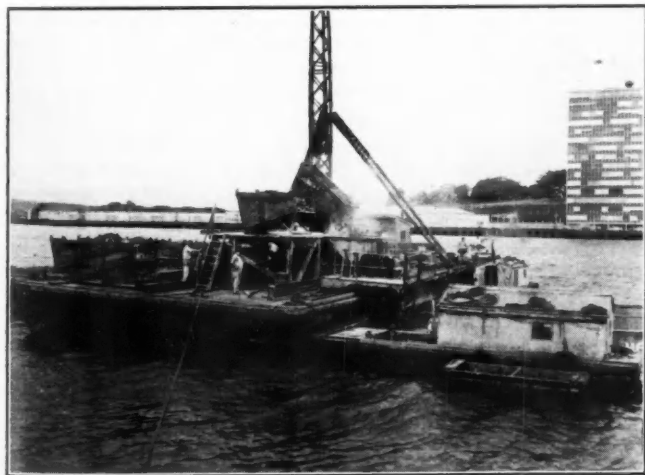
Each timber grid is supported on concrete horns projecting from the face of the sea wall and is secured by vertical steel pins which can be extracted readily from above enabling the grid to be lifted out and replaced in a minimum of time if damaged.

Caisson Design

Each caisson has a base slab 50-ft. long, 37-ft. wide and 2-ft. thick carrying external walls 12-in. thick and internal walls 8-in. thick which divide it into 6 cells. The overall height is 41-ft. 3-in. The outer walls are doubly reinforced with 3-in. minimum cover to reinforcement and form a box 50-ft. by 30-ft., leaving a 5-ft. projection of base slab to the seaward side and 2-ft. to the rear. Design strength of concrete was 3,500 lbs per sq. in. ultimate at 28 days. The pressure intensity on the igneous ballast bed under worst loading conditions was calculated at 3 tons per square foot.

Considerable investigation of the foundation material preceded the decision to use caissons. Its physical properties were determined from tests of undisturbed samples made in the Board's soil testing laboratory and at the University of Sydney.

The design provided for bedding the caissons on a 4-ft. bed of igneous ballast laid in three courses, viz. 3-ft. of 9-in. to 12-in. material, 9-in. of 4-in. to 6-in. material and a surface or screeding course of 1½-in. material. The surface course was finished with a 6-in. crossfall and provided a minimum depth of 6-in. under the heel of the caisson and 12-in. at the toe, averaging 9-in. The level and crossfall of the bed allowed for 6-in. compression in the bed and for 6-in. tilt in the caissons under the active pressure of the backfill.



Material for the upper courses of the igneous ballast bed on which the caissons were founded was placed by tremie gear mounted on a punt.

Three months after placing the last of the backfill, the caissons were found to be static with a forward cant varying from 2-in. to a maximum of 3-in., leaving them with a slight residual cant to the shore. The bed extends 50-ft. beyond the last caisson placed, thus facilitating the work of extending the wall if required in the future.

Each caisson was cast with a corrugated underside to increase the resistance to sliding. Interlocking was effected by casting them with two vertical tongues for the full height on one end

and two vertical grooves on the other. The clearances between the outer faces of the tongues and grooves was 2½-in. at the bottom increasing to 6-in. at the top to allow for articulation as the placing of backfill progressed. A clearance of 3-ft. 9½-in. was allowed between inner faces, and the two vertical pockets so formed were filled with bagged concrete lowered from above and rammed after observations showed that relative movement had ceased following the placing of the backfill. These keys



Preparation of the igneous ballast bed, placing of caissons and the sand filling of caissons proceeded concurrently.

also served to prevent the passage through the joint of fines from the backfill but, as an added precaution, seven interlocked Larsen-type piles were placed vertically hard against the caissons to cover the vertical joints prior to placing the backfill. The spaces between piling and caisson were filled with clayey material.

Preparation of Site

Work at the terminal site was initiated early in 1958 by demolition of the existing wharf and wharf sheds. This was followed by the construction of the Benoto piers to carry the landward columns of the terminal and general dredging of the site in order to remove the silt down to a firm bottom. Care was taken to avoid removing any of the ballast bank supporting the old sea wall. With the site cleared, the Board's bucket dredges were used to cut the foundation trench for the caissons. This trench had a bottom width of 50-ft. at 42-ft. below low water datum and extended some 800-ft. in a north-south direction with sides suitably battered. It was known that rock would be encountered in parts of the trench and this was broken by the Board's Lobnitz rock breaker. As spreading of foundation load was of less consequence where rock occurred, maximum finished level was fixed one foot above the general level of the trench and the thickness of igneous ballast reduced accordingly. Igneous ballast was handled in 5-ton skips loaded by navy from stockpiles established at the northern end of the site. The skips of base course material were loaded on punts and tipped into the trench according to a pre-determined plan to give a layer of reasonably uniform depth which was checked and adjusted as necessary by divers. On completion of a 50-ft. run of base course, steel rails mounted on timber were set 45-ft. apart with their upper surfaces accurately placed to the line and level of the finished bed, the inner rail being 7-in. below the outer rail. Tremie gear was used to place the intermediate and final courses. This gear consisted of a steel hopper with a gate control feeding into a vertical steel tube with a telescopic section at its lower ex-

Sydney Passenger Terminal—continued

tremity. The lower section was controlled from the deck of the punt which carried the gear and was operated to counter the rise and fall of the tide. The tremie assembly was mounted on a carriage which was windlassed fore and aft on a track which paralleled the required crossfall of the finished bed. The punt carried a steam crane which lifted the specially designed skips to a tipping platform over the tremie hopper. With a diver directing operations from below, the tremie was moved to and fro across the bed and the punt was winched along the length of the section of bed under construction. Surface course material was placed in the same way but final grading to profile was achieved by screeding. The screed consisted of a heavy R.S.J. welded to a Larssen-type pile. Two 5-ton concrete anchor blocks were placed ahead of the section, each carrying a sheave block to which a wire rope from either end of the screed passed and then returned to a handwinch mounted on one corner of the last placed caisson. The accuracy of the finished bed was a source of considerable satisfaction to all those directly associated with the work. The screed rails were moved to the next section of bed when required. All these operations, including caisson placing, were geared to the same time schedule and proceeded concurrently in closely adjacent sections.

Caisson Construction

The time schedule for construction of the terminal required the production of fourteen caissons with an output of one per fortnight, and construction installations and procedures were designed on this basis. The Board's central concrete mixing plant and concrete testing laboratory were established in the Rozelle Bay area some years ago, together with an adjacent pre-cast products depot and a bar bending shop. For the caisson programme, the depot area was extended to include the adjoining wharfage, at which three caissons could be moored, and a landward area for reinforcement assembly. The depot area embraces a lighter dock served by a travelling gantry crane of 18-tons capacity and 100-ft span which traverses the full run of the depot from the dock to the bar bending shop at the far end,

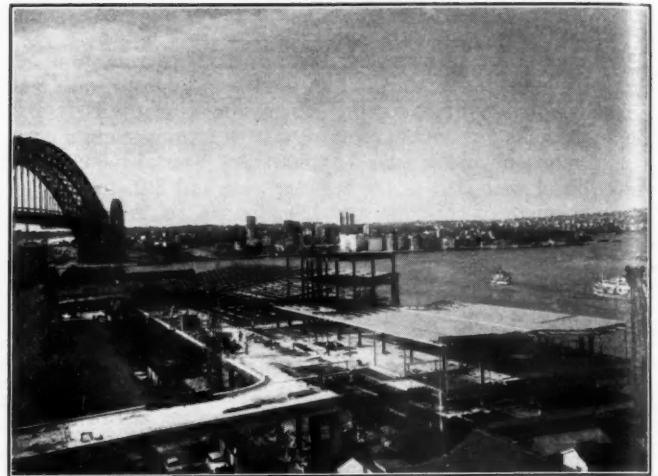


Caissons were filled with sand and the joints sealed prior to the tipping of back filling and the driving of steel foundation piling.

some 500-ft. away. The layout was excellently suited to repetition work and line-production methods. Reinforcement was assembled on jigs and tack welded to form units as large as could be handled conveniently by the available cranes.

At the head of Rozelle Bay, a waterfront depot for the storing of used building materials was converted to a caisson launching depot. Dual launching ways extending 200-ft. into the bay on a declivity of 1 in 8 were constructed on a timber piled founda-

tion. Each set of ways was furnished with a horizontal launching platform on which the caissons were constructed to a height of 17-ft. prior to launching. Two 5-ton travelling gantry cranes traversed the full length of the depot including the areas occupied by the launching platforms. Steel formwork was used in large panels for external surfaces and as complete boxes for the cells. The latter were equipped with vertical joints and cover strips which enabled the steel boxes to be contracted by means



The elevated roadway and approach bridges nearing completion, March 1960.

of manually operated union screws to the extent necessary to allow the steel boxes to be lifted from the cells intact by means of the overhead crane. The bonding bars projecting from the base slab were held in precise position prior to and during the pouring of concrete by means of light steel trusses spanning the side forms. Reinforcement for the wall pours arrived by lighter from the dock at the pre-assembly depot in large mats and assemblies which were brought together around tubular steel frames at the launching site. Each frame carried the complete reinforcement for one pair of end cells. With two of the tubular frame assemblies in position, the reinforcing mats for the outer walls of the centre cells were added to complete the placing of reinforcement for the next pour. This system enabled the assembly of reinforcement other than the final placing of the assemblies to proceed concurrently with and clear of other work on the caissons. Prior to pouring, surface cover was checked by passing a timber batten between steel form and reinforcement.

Concrete was brought from the central mixing plant, a distance of half a mile, in the Board's standard concrete trucks. These have specially designed open steel bodies of 4-cubic yards capacity and discharge the concrete through a manually controlled gate by elevating the forward end of the body with conventional hydraulic tipping gear. Concrete was discharged into the forms directly from buckets of two cubic yards capacity with narrow gate controlled exits. The buckets were handled by the overhead cranes and could be moved expeditiously and accurately to any part of the work.

During the 4-week construction period prior to launching, the caisson platform was retained in its position on the ways by means of conventional trigger gear and supplementary preventors secured to ground anchorages. The ways were greased after each launching with a 50-50 graphite grease which was selected after careful preliminary experiment and proved entirely successful in use. The build-up in weight of each caisson to 600 tons prior to launching tended to freeze the grease under the sliding ways of the platform and, generally, a slight thrust from

Sydney Passenger Terminal—continued

hydraulic jacks was needed to start each caisson on its run down the ways.

Immediately after each launching, the ways were greased and the cradle recovered. The side forms for the base slab were set up and the 4-week cycle repeated. The launched caisson, having floated free of the platform, was immediately taken in tow by launches to the fitting-out wharf further down the bay. As the construction period to completion at this depot was 6 weeks, work proceeded concurrently on 3 caissons in order to maintain the fortnightly completion schedule. In order to counter the rise and fall of the tide, the caissons at the fitting-out wharf were water-ballasted in order to keep them resting on a sand bed laid for the purpose at the face of the berth.

Placing of Caissons

As each caisson was completed at the fitting-out berth, it was towed through Glebe Island bridge to the terminal site. Three of the Board's 35-ft. launches were used for the tow and communication between the officer-in-charge and the launch drivers was maintained through the Board's wireless communication network.

On arrival, the caisson was moved into approximate position and hoses from a fire float were placed, one in each of the six cells of the caisson. Pumping was continued until the caisson had a freeboard of one foot on the landward side and eighteen inches on the seaward side, corresponding to the crossfall of the bed. As the tide fell, two divers checked the uniformity of clearance between the base of the caisson and the bed until the caisson grounded. During this period, it was strained to the previously placed caisson by means of wire ropes connected to handwinches on the caisson and to shore and offshore anchorages. As soon as the caisson was fairly grounded, the pumps were started and the cells flooded so that it would not float off on the rising tide. The general order of accuracy in placing the caissons, measured longitudinally and transversely, was approximately within two inches.

As soon as practicable after placing, the caisson cells were filled with sand. Design requirements called for a sand density of 105 lbs per cu. ft. Suitable sand was recovered from a down harbour bank by means of a grab dredge loading into 650-ton

dumb hopper barges which were towed to the site and off-loaded by floating steam crane and grab. Placing of back-fill followed the filling of the caissons.

Tops of caissons finished 3-ft. above low water datum and the 7-ft. sea wall which extended up to deck level was cast in two stages using steel forms, the lower run of which was bolted to the caissons. Fendering loads on the wall will be countered by the passive resistance of the backfill and, in order to increase this, the base slab was turned down 2-ft. into the sand fill of the rear cells of the caissons. In addition to the fendering units and the bollards, this wall carries a trench for utility services.

Because of the great horse-power of the new ships, precautions have been taken to prevent disturbance of the igneous ballast bed and the adjacent material. For the full run of the caisson wall, the toe of the wall has been protected with heavy igneous boulders placed by crane and diver to fill the forward edge of the trench from 42-ft. below datum up to dredged depth 35-ft. below datum and mounded up onto the toe of each caisson.

Conclusion

The whole of the substructure work for the terminal has been carried out by the Board's day labour organisation. The programme involved the making and placing of 14 reinforced concrete caissons for the terminal and this was supplemented by 24 caissons made for use in Darling Harbour. The 38 caissons have been built at the rate of one per fortnight.

The success of this venture into an entirely new field of wharf construction can be attributed primarily to the thoroughness of preparation in the design stages which included all phases of construction operations. The construction engineers were thus able to face their problems of organisation and management with a clear picture not only of what had to be accomplished but also of the methods of doing it.

The planning and construction of the superstructure called for close liaison between the Board's architects, design engineers and construction engineers. The West Sydney Cove Passenger Terminal may well be described as a mature product of creative planning and these three groups have good reason to be proud of the result of their combined efforts.

Lead-in Wharf for Sturrock Graving Dock, Table Bay Harbour

Amongst the most valuable assets of Table Bay Harbour, South Africa, is the Sturrock Graving Dock, acknowledged to be one of the largest docks in the world. As will be seen from the accompanying drawing, the dock is situated in the south east corner of the Duncan Dock.

Super tankers have become regular callers at Table Bay Harbour for dry-docking services, and in order to facilitate the safe manoeuvring of such large vessels, especially when winds of great force prevail, it was decided to construct a 900-ft. landing or lead-in wharf. Once this facility is completed, it will be a comparatively easy matter to bring ships to the wharf, with the aid of tugs, and thereafter to warp them into the dry dock, by means of winches and capstans.

The original scheme envisaged the construction of the wharf as a series of dolphins linked together with catwalks; but after many tests with experimental models, the final design chosen for the wharf, was of the concrete caisson type. These caissons, shown on the drawing, are 36-ft. long and 22-ft. wide, and are divided into eight compartments. Each caisson is built to a height of 43-ft. in the graving dock, prior to being floated.

Climbing steel shutters 6-ft. high are used. Concrete for the caissons is mixed at a central mixing site, and is delivered at the dock side by a pneumatic concrete placer, direct into roller type buckets, from where it is hoisted by crane, and the buckets discharged direct into the shutter. This method has been found the most economical for handling large quantities of concrete, with a minimum of labour, in the shortest possible time.

In the initial stages, some difficulty was experienced in handling the pneumatic placer, until the correct mix was evolved, and in this respect the best results have been obtained by using an over sanded mix of 48 per cent sand to 52 per cent stone, as it was ascertained that a higher proportion of stone invariably led to blockages in the pipes.

Cement is being used in the proportion of 564 lbs. to the cubic yard. To reduce segregation in the pumping operation, a plasticiser is used at the rate of .7 per cent of the cement weight, which also improves the density and general quality of the concrete.

The water cement ratio plays an important part in successful pumping, and it has been found that it should be within the range of .42 and .6 and the best results being obtained with .48. The concrete was vibrated throughout by an immersion type vibrator.

After overcoming the initial difficulties, good results were obtained from the concrete, and on floating a caisson there was no vestige of a leak, even though frogs are not formed in the con-

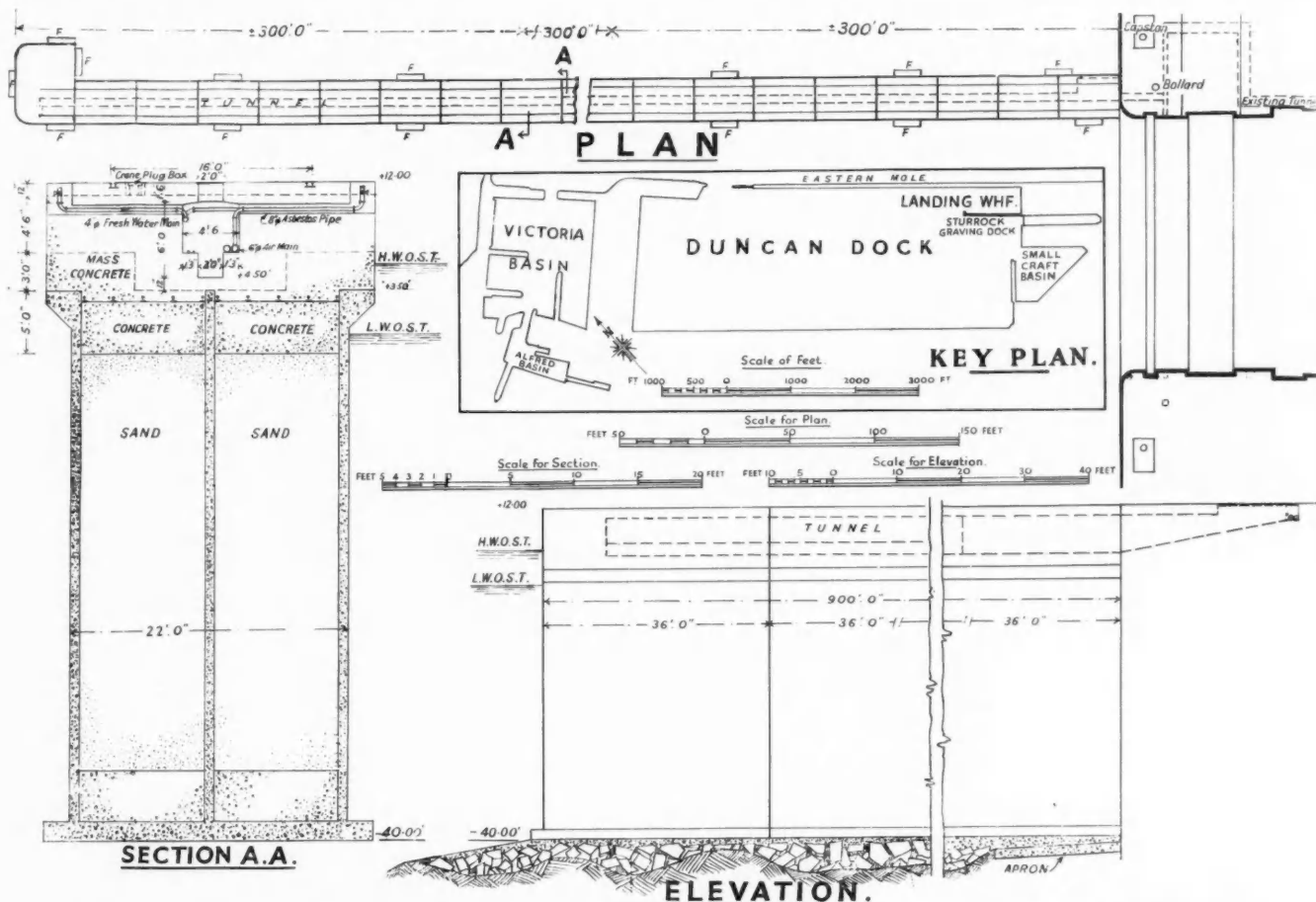
Lead-in Wharf—continued

struction joints. This fact was even more remarkable, for on occasions there have been stoppages of anything up to six days between casts.

Under normal conditions, it takes eleven days to do the seven lifts to complete a caisson to its full height. Eight hours are required to lift the shutters, and the concreting of each six foot lift necessitates another three to four hours.

The fendering will be the standard roller type fenders, as used in the harbour, and will consist of motor car tyres, stuffed with old coir ropes, carried on a timber baulk, and suspended by chains at three points on the wharf face. These have proved most economical, and effective, even under excessive range conditions.

The fender treatment at the end of the wharf will be different,



Plan, Elevation and Cross-section of the new Landing Wharf and Key Plan showing the Duncan Dock, Table Bay Harbour.

To ensure that the caissons will float when the dock is flooded, and are not held to the floor by suction, they are built on a porous bed of stone, the surface of which is grouted.

The caissons are being constructed in batches of six, but are floated one at a time, and towed to the site where they are carefully lined up before being sunk on a prepared foundation, which is excavated to rock by a grab dredger, the final cleaning up is done by an air lift pump. Once this is done a stone bed is laid and carefully levelled.

After sinking the caisson on this foundation, the stone is grouted with colgrout through pipes in the floor of the caisson, which forms a solid foundation, and prevents any further settling or movement.

The compartments of the caisson are filled to -1.5-ft. below L.W.O.S.T. with sand. To complete the caisson to wharf height, a mass concrete capping is added, in which is included a tunnel for the various services such as water, oil, power, telephone cables and compressed air.

It is the intention to equip the wharf with bollards on both sides, so that apart from serving as a leading-in wharf, the eastern side can be used as a repair berth.

in that the curved portion is to be protected by a combination of tubular and square rubber fenders.

Two 20-ton capstans will be installed at the end, and the middle of the wharf, to facilitate the warping in process.

The total estimated cost of the project is £260,000.

Plan for New Tanker Berth at Table Bay

A plan to build a new, permanent tanker berth at Table Bay Harbour, which has been under consideration in Johannesburg for the last two or three years, is now being actively studied. The proposed site is planned for the area between the Eastern Mole and the new 900-ft. lead-in wharf to the eastern entrance of the Sturrock Drydock, the construction of which is described above. After dredging, the new tanker berth would be able to accommodate 42,000-ton vessels.

The existing oil berth at the Eastern Mole has always been regarded by the port authorities as being a temporary and unsatisfactory facility. In the case of a tanker explosion, oil or petrol could be spread over a wide area of the Duncan Dock and with a south-east wind might endanger the mailship berth. The proposed site would obviate this risk.

Dredging in Naval Ports

Review of Varied Types of Craft Employed*

By B. J. Vickars, B.Eng., M.I.C.E.
(Command Navy Works Officer on staff of Commander-in-Chief,
Portsmouth)

DREDGING requirements in naval ports and bases necessitate an organization which allows of considerable flexibility and the role of the Director-General, Navy Works, Admiralty, in analogous to that of a dredging contractor who, at short notice, must be able to undertake work in any part of the world under widely varying conditions.

There are four major naval ports in the United Kingdom and three abroad where maintenance dredging in varying quantities is a continual commitment and capital dredging may arise at any time. For maintenance each port has craft based locally to cope with the clearance of silt from berths, entrances to docks, locks, and basins. In dockyards where comparatively little siltation takes place, the work is undertaken usually by dumb pontoon grab dredgers. Where siltation is beyond the scope of these small vessels, self-propelled hopper grabs are employed which have been designed to meet the requirements of the particular port and are capable of coastal passages to take on work in small naval bases elsewhere. For large maintenance jobs in the ports generally, and capital dredging at home and abroad, a fleet of sea-going bucket dredgers and self-propelled hoppers is available. This fleet is based at Portsmouth, under the direct control of the Manager of Navy Works, and there it is manned and maintained.

Brief details of the Admiralty craft at present in commission are given in Appendix I. The following descriptions and remarks concern the various types of craft.

Dumb Grab Dredgers

Dumb grab dredgers work with dumb barges of 100 and 180 cu. yds. capacity, which are towed by general service tugs and form economical units when working in the corners of the dockyards and particularly in closed basins. Having light moorings and being easy to handle with a small crew, they can be moved quickly to make way for the movements of ships. The W.11-W.14 are of a prefabricated sectional design developed in the 1939-45 war; the dumb hoppers are of similar design. They were given the name of "Mintoons" and "Minhops" and proved to be of immense value because of the ease with which they could be transported overseas. Fabrication was all by welding. As the pontoons have flat bottoms and square ends they do not tow well, and need to be carefully prepared for passage. If a pontoon-type craft is required to travel between ports, it is preferable that it should have ship-shape ends and rounded bilges. All-over decking is essential if dredging is contemplated in open water or where there is danger of a heavy wash from passing ships.

The W.18 has recently been transported by merchant ship to an island in the Pacific, where it successfully dredged a channel through a coral reef and cleared an area for berthing (see Fig. 1). The pontoon and crane were taken out in one piece, the lift being 96 tons. A heavy duty grab was able to remove the soft surface

coral, but the harder underlying material needed breaking up by an improvised chisel.

Self-propelled Hopper Grabs

The St. Martin and the St. Giles have been designed and built to meet normal maintenance dredging at Devonport and Rosyth Dockyards (Fig. 3). They are thoroughly sea-worthy vessels capable of carrying their full loads of spoil to sea in most weathers and of making coast-wise passages. These vessels are "maids of all work" and carry out miscellaneous tasks in connection with navigational marks, pile extraction, boring, and general civil engineering work.

In practice the rated output of a grab dredger over a period is rarely achieved, largely because grab dredgers are normally operated in confined waters where constant interruptions are caused by the movements of ships and harbour craft. Moreover, one of the biggest problems in naval dockyards is the removal of miscellaneous debris and materials which invariably accumulate at berths, despite the instructions against dumping of such items, and which occupy a considerable amount of dredging and dumping time, while contributing nothing to measurable output. While the lifting of this does not present a serious problem for a grab, handling and disposal is a tedious and time-wasting operation.

The Dutch have recently produced a tipping barge which, when loaded, is dumped by inverting it; it can then be loaded on the reverse side, thus ensuring a clean dump. This may very well be the solution to the disposal of debris in ports where dumping in sheltered water is permissible.

The average speed of the St. Martin and the St. Giles is about 8 knots, which is economical for hauls of up to about 15 miles each way. When longer trips are involved, speeds of 12 knots are quite common, but the higher speeds are usually associated with large-capacity craft. Two triple-grab dredgers employed by the Mersey Docks and Harbour Board are in operation in the Mersey, each having a hopper capacity of 1,350 tons and a speed of 12 knots; these two vessels together can dredge and dump a total of 1 million tons of mud annually. On the question of speed it is thought that consideration might be given to the fitting of variable-pitch propellers which would enable a higher speed when returning empty, at some sacrifice in efficiency when under-way loaded.

While the Admiralty dredgers normally operate in sheltered waters they have on occasions worked in the open sea, and have been employed successfully in exposed positions on the north-east coast of Scotland and the west coast of England; in fact, in positions where no other type of dredger could have been employed.

The output of a grab dredger depends to a large extent upon using the right type of grab for the material dredged. Where the bulk of the work is in one material, it is essential to ensure the right classification by proper analysis. The following information, produced by Messrs. Priestman Bros., Hull, gives a guide to the types of grab available and their efficiency for the different grades of material:—

* Paper (slightly abridged) presented in London last June at a Conference on Civil Engineering Problems Overseas and reproduced by kind permission of the Institution of Civil Engineers.

Dredging in Naval Ports—continued



Fig. 1 (left). Grab of W18 lifting a piece of coral.

Fig. 2 (above). Bucket ladder of "St. Alban" showing rock picks.

Material	Type of grab usually recommended	Approximate proportion of material lifted to lifting power of dredging crane: per cent
Mud and silt	"Mud" (clam-shell)	66
Plastic clay	"Heavyweight" (clam-shell)	47
Stiff clay	"Wholentine" (clay tines)	30
Free sand and gravel	"Mediumweight" (clam-shell)	55
Medium hard sand and gravel	"Heavyweight" (clam-shell)	45
Hard sand and gravel	"Wholentine" (pick point tine)	30
Broken rock (up to 6-in. pieces)	"Heavyweight" (clam-shell)	38
Broken rock (up to 1-ft. pieces)	"Wholentine" (rock tines)	25

For example, if a $5\frac{1}{2}$ -ton grab-dredging crane is to handle mud, then it can be estimated that the approximate amount lifted at each operation will be 66% of $5\frac{1}{2}$ tons, approximately $3\frac{1}{2}$ tons.

Sea-going Multi-bucket Dredgers

The St. Alban is a twin-screw stern-well dredger with a hopper capacity of 1,000 cu. yds. and a loaded speed of 10 knots. The rated output in free-getting material is 700 cu. yds./hour, using 28-cu. ft. buckets. The vessel is equipped for rock dredging with a second bucket chain having buckets of 14 cu. ft. capacity and special ripping claws or picks. These are of cast steel with renewable manganese steel tips and are fitted one to every four buckets (Fig. 2). The 4-in.-dia. bucket pins are of manganese steel and the links have manganese steel bushes. The bottom and top tumblers are hexagonal and pentagonal, respectively, which, in this type of dredger, comprise the best combination to give a smooth and efficient motion to the bucket chain. Wearing

plates of cast steel were originally bolted on to the faces, but it has been found more satisfactory to weld them and to make up the wear by weld reinforcement which can, if necessary, be carried out in situ.

The bucket ladder is of sufficient length for the vessel to cut her own flotation, and the normal dredging depth is 50-ft. By lowering the ladder to an alternative suspension point, a depth of 75-ft. is obtainable and a jockey ladder and additional buckets are fitted to give extra length of chain. This extra depth is necessary when dredging deep berths for large floating docks. The upper tumbler is driven by shaft and gearing, power being supplied from either main engine.

This dredger has worked in ports as far apart as Rangoon and Bermuda, and is able to travel with the catenary of the bucket chain secured clear of the water and all buckets fixed. In this trim it has weathered heavy gales on ocean passages.

One of the requirements specified for this vessel was that it should be capable of removing the hardest material possible to be dredged in normal bucket-dredger practice, without blasting. This requirement has been fully met, and some extremely tough virgin rock in various parts of the world has been readily handled. During the past 4 years the St. Alban has been dredging rock in the Mediterranean. There is no doubt that the ripping claws which were developed by the Admiralty, and are believed to be unique, have made it possible for this dredger to tackle hard rock so successfully.

The employment of a heavy dredger with its own hopper in free-getting material is costly, since the ratio of dredging time to total hours worked is low and much time has to be spent in handling heavy moorings and in manœuvring. On the other hand, when working in hard material, the output is comparatively small and the use of hopper barges is not economical. It has been found in practice that when dredging hard rock it is often impossible to keep a hopper moored securely alongside, as the vessel tends to surge forward as a bucket clear the rock face. When dredging in free-getting material, it is economical to use hopper barges and to keep the hopper of the dredger as a reserve.

Dredging in Naval Ports—continued

As a measure of the capacity of this vessel, records show that while dredging virgin coral in Bermuda and self-loading, it dredged and deposited 3,600 barge-yards per 60-hour working week, the distance to the dumping ground being 3 miles. Working in free-getting material and using three hopper barges, it has raised 56,000 barge-yards per 60-hour working week. The capital cost of a heavily constructed dredger of this type is high (in 1940, £151,000), but bearing in mind the expense and time required to break up rock with a rock-breaker, or by blasting, the vessel has been a sound economical proposition.

The St. Abbs and the St. Ives are bow-well single-screw vessels which were built to Ministry of Transport requirements in 1945, and taken over by the Admiralty in 1946. They have no hoppers and are sea-going vessels but, having a bow-well, they are not so seaworthy as the St. Alban. In bad weather steering is difficult and some towing assistance from a hopper barge or tug is often necessary. Some improvement in manoeuvrability has been effected by a plate having been fitted across the forward end of the well, which reduced the effect of wave action in the well. Both the vessels are equipped with 28-cu.-ft. mud buckets, and the St. Ives has also a spare set of 14-cu.-ft. rock buckets, with which she has dredged a hard limestone in Portland Harbour. Power is supplied to the bucket chain by shafting and gearing.

There is a wide divergence of opinion among engineers on the question of power transmission from engines to bucket chain. Some strongly advocate belt-drive which undoubtedly reduces overloading by slipping when a bucket suddenly and unexpectedly strikes rock or a heavy obstacle. It does, however, suffer from the obvious disadvantages of reducing the maximum power available for heavy dredging. The St. Abbs and the St. Ives are fitted with friction clutches in the main spur wheels driving the top tumbler, and the St. Alban has a similar device working on the speed-reduction shaft. These are designed to slip under extreme load, but the adjustment is rather on a "hit and miss" affair, and there is no positive means of ensuring that a safe working torque is not exceeded. There is, therefore, a lot to be said for diesel or diesel-electric drive as the introduction of a fluid coupling is practicable.

All Admiralty dredgers have steam-driven machinery with oil-fired boilers, and this plant has given excellent and reliable service. Opinions are divided on the question of Diesel, Diesel-electric, and steam-driven machinery. The former is popular with Continental designers, but in the United Kingdom steam still seems to be favoured. It is not uncommon for the engines of a bucket dredger to be brought to a standstill when dredging tough material, and on occasions the St. Alban has surged forward, as a result of a recess in the rock face, to such an extent that the bucket chain and main engine have been reversed. There is a lot to be said, therefore, for the reciprocating steam engine; it is robust and simple and will continue to work with a minimum of skill and attention, which is an invaluable asset for a vessel having to work in places where adequate maintenance facilities are not readily available.

From the economical point of view, Diesel-driven vessels have advantages; the machinery takes up less space, reduces the overall dimensions of the vessel, and is cheaper to run. No boiler room staff is required, and time and money is not wasted on periodical boiler cleaning, retubing of boilers, and maintenance of ancillary machinery. On the other hand, these savings are offset to some extent by the higher degree of skill and maintenance required to keep Diesel engines running efficiently.

The maintenance costs of bucket dredgers are high, because there are so many wearing parts in the dredging gear working under heavy stress and the worst possible conditions. Tumblers, bucket-pins, and links are constantly being drenched with mud, and the wear and tear on the bearings is a major problem.

In 1958 a system of automatic lubrication was fitted on the St.

Abbs and a reduction in wear and tear is already noticeable. The top tumbler-bearing, ladder roller-bearings, and the lower sheaves of the ladder suspension are all fed with grease at 30-min. intervals by an automatic electrically driven pump working up to a maximum pressure of 1,500 lb/sq. in. The consumption of grease is approximately 10 lb/day. A separate system, served by another pump, supplies continuous lubrication to the bottom tumbler at 450 lb/sq. in., and this consumes about 10 lb/week of special under-water grease. The fitting of the system presented no difficulty, but the protection of the feed pipes and connections to the bearings against damage by debris raised by the buckets was a problem which needed some careful thought.

The servicing of these vessels would have been made easier and the maintenance costs reduced had there been some standardisation of the dredging-gear components. As dredgers, in common with other ships, are built to owners' specifications, it is not practicable to adopt much standardisation in design, but for an Authority, operating more than one vessel, a standard design of components in relation to the bucket capacity would ease the problem of maintenance. A standard specification for the material most suitable for use in the components would also help. Manganese steel (1% carbon, 12% manganese) has been used extensively for many years, and although it is a tough material which hardens under stress, it has a low yield point and has not proved entirely satisfactory, especially for the use of bucket pins. An alloy steel of nickel-chromium-molybdenum was used successfully for pins on a dredger working in Bombay as far back as 1924, and it has been recorded that the pins showed a wear of only 11/32-in. after 3½ years of continuous dredging. Pins of this material have recently been fitted in the St. Abbs, but it is too early to compare their qualities with those of manganese steel. The cost is about 90% greater than manganese steel; so a considerable reduction in wear and tear is necessary to make the use of a nickel alloy an economical proposition.

Figures quoted for the output can be extremely misleading and mean very little unless accompanied by full details of the conditions under which the craft were working. The only yardstick is the rated output; that is, the maximum output obtainable worked for a short period under ideal conditions. In practice the average output falls far short of the figure quoted, and it has been stated that Dredging Masters can rarely achieve more than 30% of the rated output on general maintenance work. Over a period of 10 years the St. Abbs and the St. Ives have together averaged a total of 1,300,000 barge yards per annum, working in various ports in the United Kingdom and in materials ranging from silt to virgin limestone rock. The average hours worked were fifty-five a week. The vessels working together at their rated output would have removed this quantity in approximately twelve working weeks. It can be said, therefore, that including all time lost on refits and running repairs, etc., these dredgers during the past 10 years have averaged about 23% of their maximum rated output. As the vessels age so the dredging time lost for repairs and replacements will tend to increase, and the output figure decrease.

Suction Dredgers

It will have been noted that there are no suction dredgers at present in Admiralty service. From 1910 to 1934 the St. Lawrence, which was a cutter suction dredger with 1,500-cu.-yd. hopper, was employed on general service. It was used first for the capital dredging at Rosyth and was not entirely successful. It was found impossible to retain more than 50% of the solid matter in the hopper when dealing with the silt, and the presence of boulders and stones in the clay gave rise to trouble with the cutter and pumps.

Experience showed that this vessel was not suitable for Admiralty work, because of the wide variety of material existing

Dredging in Naval Ports—continued

in naval ports, and because she was not easily manoeuvrable in confined waters.

Undoubtedly, suction dredgers are ideal for working in sand and gravel and on reclamation work. They are capable of extremely high outputs and a Paper¹ by Chatley gives some very interesting data on this type of vessel.

Self-propelled Hopper-barges

Details of these vessels are given in Appendix I (4), and some attempt has been made to standardise. The seven steam-driven hoppers are the minimum necessary to serve adequately two bucket dredgers in general service, taking into account the loss of services of a hopper while being refitted. Most dredging-dumping cycles can be economically met by the use of various combinations of the large- and medium-capacity hoppers. On coastal passages these vessels sail in company with the dredger and in bad weather a large hopper is used to give towing assistance to the dredger. These barges are fitted with heavy-duty winches for handling the dredger's moorings.

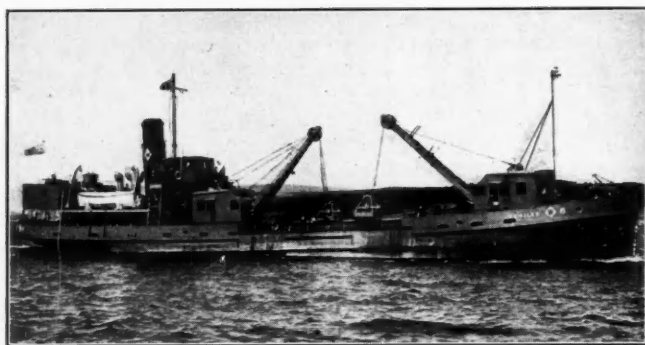


Fig. 3. The "St. Giles." Twin-grab dredger for general maintenance.

The small Diesel craft are used normally with dumb-pontoon grabs and are conveniently dimensioned for operating inside closed basins and in shallow berths. They were built to a standard design and manufactured in sections for transport and assembly in places where slipping facilities were available.

During the 1939-45 war W.27 was adapted for experimental work in connection with the laying of a flexible fuel-supply line (PLUTO) across the English Channel. Recently, an 80-ft. pile-driving frame was fitted across the hopper-well of W.30, and she then steamed from Portsmouth to the west coast of Scotland and drove 90-ft. steel box piles, each weighing about 7½ tons.

Rock Breaker

For breaking up rock which is too hard for a bucket dredger a dumb-pontoon rock breaker has been used since 1924. The pontoon, which is 120-ft. long x 37-ft. wide, and has a draft of 4-ft., carries the gear and steam plant necessary to operate a 30-in.-dia. steel chisel weighing 15 tons and working in a vertical tube weighing 9 tons.

The removal of rock by this means is a tedious process and requires considerable experience and skill. Extremely accurate positioning of the craft at the intersections points of a close grid is essential if the breaking effect of the chisel is not to be lost by allowing the point to wander. Effective work can only be carried out under good weather conditions and in areas where accurate fixes can readily be obtained. A tolerance of 2-ft. is generally allowed for irregularities and broken rock which cannot be completely cleared from the bottom. It is a wise precaution to sweep the area with a heavy horizontal steel bar slung between two heavy launches or tugs to ensure that no pinnacles of rock remain above datum level.

Maintenance of Craft

All efforts are made to dock each vessel for a major refit every 2 years and all work on the hull, machinery, and dredging gear is undertaken according to a programme based on a defect list and survey reports. Biennial refits are considered essential to maintain the craft in an efficient working condition, and it has been found that when this period has been unavoidably extended the incidence of breakdowns tends rapidly to increase.

Cathodic Protection

During the docking of the grab dredger, St. Martin, in 1954, it was observed that there were areas of severe pitting in the outer bottom plating and a considerable number of rivet heads had corroded badly. On the advice of the Admiralty Scientific Service it was decided to apply cathodic protection. First, the pitting was made good by welding and the defective rivets were replaced. The hull was then wet-sand blasted and three coats of anti-corrosive and one coat of anti-fouling paint applied. Arrangements were made to provide suspended magnesium anodes evenly dispersed around the hull and in the hopper moorings. Six 22-lb. anodes were used for the hull and two for the well; a potential of 0.85-0.9 V against a silver reference electrode was obtained for the well and 0.85 V for the hull.

The vessel was docked in 1955 and again in 1957, when only slight rusting of a superficial nature was found to have taken place. The areas previously welded and the new rivets were found to be in good condition and the hopper plating satisfactory.

In the past year, a hopper barge was protected by zinc-alloy anodes welded to the hull. Each anode weighed 48-lb., and five were fixed to every 1,000-sq. ft. of wetted hull surface. During 8 months working the average potential reading was maintained at 0.86 V, which indicated that there had been no appreciable decay of the anodes. If the potential drops, it can be temporarily boosted by the hanging of portable anodes in protective rope baskets over the side and the fixed anodes replaced when the vessel is next docked.

One of the major problems is the deterioration of the paint in the vicinity of the anodes as a result of the applied current. The normal paint used for ships' bottoms is attacked by the alkali produced which causes it to flake off. It is necessary, therefore, to use an alkali-resistant paint, and on the hopper barge recently treated, two coats of coal-tar epoxy and one coat of Admiralty anti-fouling paint were used.

Dredging and Reclamation Problems

Portsmouth Harbour is a natural one, about 15 sq. miles in extent, with a narrow entrance only 250 yds. wide through which flows a strong tide. The strength of the ebb is about 4.9 knots and the flood 3.3 knots at mean spring tides. No appreciable siltation is caused, therefore, in the harbour or main entrance channel from seaward, and, since there are no rivers of any size discharging into the harbour, maintenance dredging is confined to clearing berths of debris and material deposited by tidal action on the harbour bed.

Problems likely to arise if reclamation were carried out inside the harbour have exercised the minds of engineers for many years. In 1814 Sir John Rennie was commissioned by the Board of Admiralty to report on a proposed extension of the dockyard by about 28 acres. One of his main concerns was that the reclamation of such a large area would reduce the tidal basin and "so occasion an injury to the harbour". He recommended that an equal area be dredged higher up the harbour, so that the velocity of the ebb would be increased in the last quarter when the scouring effect was at its greatest.

Much dredging has been done in the harbour since the beginning of the 19th century with a consequent increase in the tidal flow. This has had the effect of gradually reducing the build-up

Dredging in Naval Ports—continued

of the material on the inner bar but, at the same time, has increased the scouring effect of the tides through the entrance, thus making it necessary to undertake protective works to prevent undermining of wall foundations.

With the rapid developments in recent years in the City of Portsmouth, the space available for building on Portsea Island is now almost non-existent, and schemes for reclaiming areas in the north and east of the harbour have been contemplated (see Fig. 4). The Admiralty have also considered the possibility of disposing of dredging spoil by reclamation to avoid the long haul to sea. Again, the effect of this work on the tidal flow in the main channels was in doubt and it was decided to investigate the problem by means of a tidal model. In 1947 the Hydraulics Research Station, Wallingford, Berkshire, was requested to undertake the investigations, and a model was made of the harbour to a scale of 1:480 horizontal and 1:60 vertical. The bed of the area inside the harbour was rigidly moulded in concrete, and the bed to seaward was moulded in sand of mean grain size 0.15-0.20 mm. Tides were simulated by means of a pneumatic generator fully automatic in operation.

The conclusions reached from these experiments were that the current velocities in the navigation channels would in general be reduced by as much as 25% but, as there was practically no material in suspension, no siltation would result. It was also established that, as the ebb velocity would still be greater than the flood, there would be no siltation from material entering the harbour. It was thought that the disposition of material on the inner bar might change and, although the area might increase, it would not be accompanied by a substantial increase in vertical growth.

The model was also used to consider the local effect in the harbour of a proposal to undertake capital dredging in one of the main creeks adjacent to the entrance. This investigation indicated that there would be no serious increase in the size of a ballast bank, and that the current velocities, which at that point are a hazard to navigation, would in general be reduced.

Rosyth Dockyard is situated on the north bank of the Firth of Forth, about 30 miles from the open sea and $2\frac{1}{2}$ miles upstream from the Forth Bridge. The works were commenced in 1909, and the main basin was brought into use in 1916 on completion of the dredging of the approach channel. The construction of the dockyard formed the subject of a Paper² by Hunter and Bell. Between 1913 and 1922, approximately 17 million barge yards of material were dredged from the river to provide berthing facilities and a main approach channel to the dockyard. From 1924 to 1945 maintenance dredging averaged just over $\frac{1}{4}$ million barge yards per annum.

The approach channel runs parallel to the main river channel and is separated from it by a shallow bank; the depth in the former is now maintained at 32-ft. below chart datum. The major part of the river bed is a soft "sleech" mud which, in the Rosyth area, moves backwards and forwards under tidal action. This causes siltation in the approach channel, and considerable thought was given to the possibility of reducing this by constructing a training wall to increase the rate of flow of the ebb tide through the channel, but it was uncertain what the effect of this would be on the regime of the river. It was decided, therefore, to investigate the problem by means of a tidal model which could also be used for the examination of proposed development works in the dockyard.

In 1944 the National Physical Laboratory, Teddington, was asked to carry out the investigations, and Professor Jack Allen, D.Sc., M.I.C.E., of Aberdeen University, was appointed as consultant for the preliminary design of the model. In 1947 the responsibility was transferred to the Director of the Hydraulics Research Station, who prepared the final report.

The scales adopted for the model were 1:1800 horizontal and

1:144 vertical. The length of river covered was approximately 32 miles, making the model length 94-ft. Many combinations of training-wall design in open and solid construction and at various heights and lengths were tried out. The formation of a fish-shaped island on the shallow bank was also tried with a view to diverting a part of the main ebb tide through the approach channel. The report of these investigations covered about sixty pages; the conclusion reached was that a training wall, 1,700 yds. long, in solid construction above H.W. level would result in some reduction in siltation in the approach channel. Due to the difficulty in observing the very low velocities in the pocket between the proposed wall and the dockyard, it was impossible to assess with any precision the extent of the reduction. It was decided, therefore, that the extremely high cost of building such a training wall was not justified, and that there was no reliable way of reducing the rate of siltation at an economical cost. The



Fig. 4. Portsmouth Harbour showing proposed areas for reclamation.

conclusion reached on the question of reclaiming areas adjacent to the dockyard was that the cubature of the estuary above Rosyth would be reduced by about 11%, and that the tidal flow would be reduced in the same proportion. Because this would have affected the regime of the river and probably resulted in greater siltation, it was decided not to consider further reclamation schemes.

In the contract for the original dredging of the approach channel, allowance was made for reclaiming an area to the east of the dockyard. The method employed was to form ponds inside banks of tipped dry filling and then to pump ashore the dredged spoil. The latter consisted of a fine silt, heavy clay, and stones varying in size from gravel to large boulders, and large quantities of water were necessary to break up the clay for pumping. The result of this was that the stones and heavy material formed hard ridges across the area, interspersed with ponds of

Dredging in Naval Ports—continued

extremely soft slurry. The area has, therefore, always been a treacherous one for foundations and created difficulties with road works and services. The reclaiming of this area with dry earth filling would have been a much more economical proposition, even if the initial cost has been higher, which is doubtful, since the cost of pumping ashore was actually about 2s. 6d./cu. yd. It has been found from test pits put down in recent years that ponds

of slurry still exist at about the same consistency as when the material was pumped more than 40 years ago.

REFERENCES

- 1 Herbert Chatley, "Dredging machinery". J. Instn civ. Engrs, vol. 24 (April 1945), p. 72.
- 2 T. B. Hunter and A. L. Bell, "H.M. Dockyard, Rosyth". Min. Proc. Instn civ. Engrs, vol. 223 (1926-27), p. 37.

APPENDIX I

ADMIRALTY DREDGING CRAFT—1959

(1) Bucket dredgers

Name	Makers and name	Type	Gross tonnage	Overall length: feet	Beam: feet	Max. draft: feet	Speed: knots	Machinery	Remarks
St Alban W.1	Lobnitz & Co., 1940	Stern well twin screw	1,790	279	47½	13½	10.5	Steam triple expansion, I.H.P. (Indicated Horse Power) 1,600	Dredging depth: Normal—60 ft Maximum—75 ft Rated output—700 cu. yd./hour Hopper capacity—1,000 cu. yd
St Ives W.2	Fleming & Ferguson, 1945	Bow well single screw	938	204	40	11½	8.5	Steam triple expansion, I.H.P. 700	Dredging depth—55 ft Rated output—865 cu. yd./hour
St Abbs W.3	Simons & Co. Ltd, 1945	Bow well single screw	512	160	36	11½	7.8	Steam compound expansion, I.H.P. 700	Dredging depth—50 ft Rated output—766 cu. yd./hour

(2) Self-propelled grab dredgers

Name	Makers and date	Tonnage: gross	Length: feet	Beam: feet	Max. draft: feet	Speed on trials: knots	Hopper capacity: cu. yd	Machinery	Grab cranes	Remarks
St Giles	Fleming & Ferguson, 1951	618	175	33	10½	8.8	400	Steam triple expansion, I.H.P. 343	2 No. Priestman steam-driven, No. 50	Rated output—400 cu. yd/hour at 40 ft Maximum dredging depth—70 ft
St Martin	Fleming & Ferguson, 1951	389	144	30	8½	9.0	200	Steam triple expansion, I.H.P. 358	1 No. Priestman steam-driven, No. 50	Rated output—200 cu. yd/hour at 40 ft Maximum dredging depth—60 ft
Servitor	Fleming & Ferguson 1935	572	174	32	11½	9.7	450	Steam triple expansion, I.H.P. 609	2 No. Priestman steam-driven, No. 40	Rated output—200 cu. yd/hour at 40 ft Maximum dredging depth—70 ft

(3) Dumb grab dredgers

No. of vessel	Home port	Makers and date	Length: feet	Beam: feet	Draft: feet	Dredging equipment	Remarks
W.11 W.12 W.13 W.14	Singapore Malta Hong Kong Portsmouth	Priestman Bros. Ltd, 1946	70	27	3½	Priestman steam crane, type No. 50. 55/44-cu.-ft grab. 27-ft radius	Prefabricated construction to standard designs. Mintoons
W.18	Chatham	Priestman Bros. Ltd, 1891. Rebuilt 1945	67½	19½	2½	Priestman crane, 60-B.h.p. national Diesel engine	Transferred for work in Pacific
W.19	Gibraltar	H.M. Dockyard, Gibraltar 1927	61	27	3	Steam crane by J. H. Wilson & Co. 3 grabs	
W.20	Chatham	H.M. Dockyard, Portsmouth, 1952	61	24	3½	Priestman crane, 3 mud grabs. 48 cu. ft. 1 whole tine grab. 26 cu. ft	
W.21	Malta	H.M. Dockyard, Malta, 1932	61	26	3½	Crane by A. Jack & Co. Ltd. 1 rock grab. 30 cu. ft	
W.15	Gibraltar	Harland & Wolfe Ltd, 1958	70	27	3½	Priestman crane, type No. 50. 27-ft radius. 55/44-cu.-ft grab	

(4) Self-propelled hoppers

No. of vessel	Builders	Year built	Dimensions				Hopper capacity to deck level: cu. yds.	Machinery	Speed loaded: knots	Remarks
			Length overall: feet	Beam: feet	Moulded breadth: feet	Waded draft: feet				
W.26 W.27 W.28	Fleming & Ferguson	1938 1938 1928	206	35	15½	13½	900	Steam triple expansion twin screw, 1 h.p. 1443	11	
W.29 W.30 W.31 W.32	Simons & Co.	1944 and 1945	167	33	15	12½	650	Steam triple expansion twin screw, 1 h.p. 1,000	10	Built to Ministry of Transport specification. Taken over by Admiralty in 1946
W.33 W.34	Dowsett & Co.	1947	125	23½	11	8½	300	Diesel Mirrlees 6-cyl. single screw	7	Standard prefabricated design. Assembled in Chatham dockyard

Repiling a Jetty Under Traffic Conditions

By J. P. M. PANNELL, M.B.E., M.I.C.E., M.I.Mech.E.
(Engineer to Southampton Harbour Board)

The Town Quay, Southampton, originally a medieval quay, was progressively extended in the nineteenth century and is now a piled jetty about 1,500-ft. long and 120-ft. wide. It has successively been piled with timber, cast iron and reinforced concrete. It is owned and operated by the Southampton Harbour Board and is extensively used for Isle of Wight, coastwise, and near continental traffic. The increase of draft required by ships using the Quay in the post-war years has necessitated a progressive deepening alongside the berths and this has called for a constant review of the foundation levels of the piling. A recent requirement for deepening one of the berths, No. 13, to 20-ft. led to the need to supplement the existing outer row of piling as the records showed that these piles, of the Mitchell cast iron screw type, were at too shallow a depth for security.

No. 13 Berth is so situated on the Quay that its closing would not only reduce the berthing space available, but also seriously interfere with railway connections to two important berths on the seaward side. It was therefore important that any reconstruction should, if possible, be carried out without any major interference with traffic. The works were accordingly designed with this object as a main requirement.

It was therefore decided to use the new continuously welded steel casings of the British Steel Piling Company, driven by an internal drop hammer through holes cut in the existing reinforced concrete deck.

These casings are manufactured from steel strip by the Driam patented process. The plate is formed into a continuous helix and the seam is welded automatically by the submerged arc method in two passes, one inside and one outside. The casing chosen was 14-in. diameter and 8 gauge (0.160-in.) in thickness. One great advantage of this type of casing is the ease whereby the pile length may be altered to suit varying ground conditions, additional lengths being easily welded on as required. The tentative pile length ordered was 45-ft. as previous experience had shown that piles in the area usually found hard ground about that depth below the deck level. Thirty piles were required and they were supplied with one end blanked off with a plain circular plate of $\frac{1}{2}$ -in. thickness. The makers had claimed that this type of base would be satisfactory in driving and this claim was entirely borne out in practice. With the exception of one pile, which appeared to have struck a hard obstruction and deviated an inch or two, all piles went down perfectly plumb.

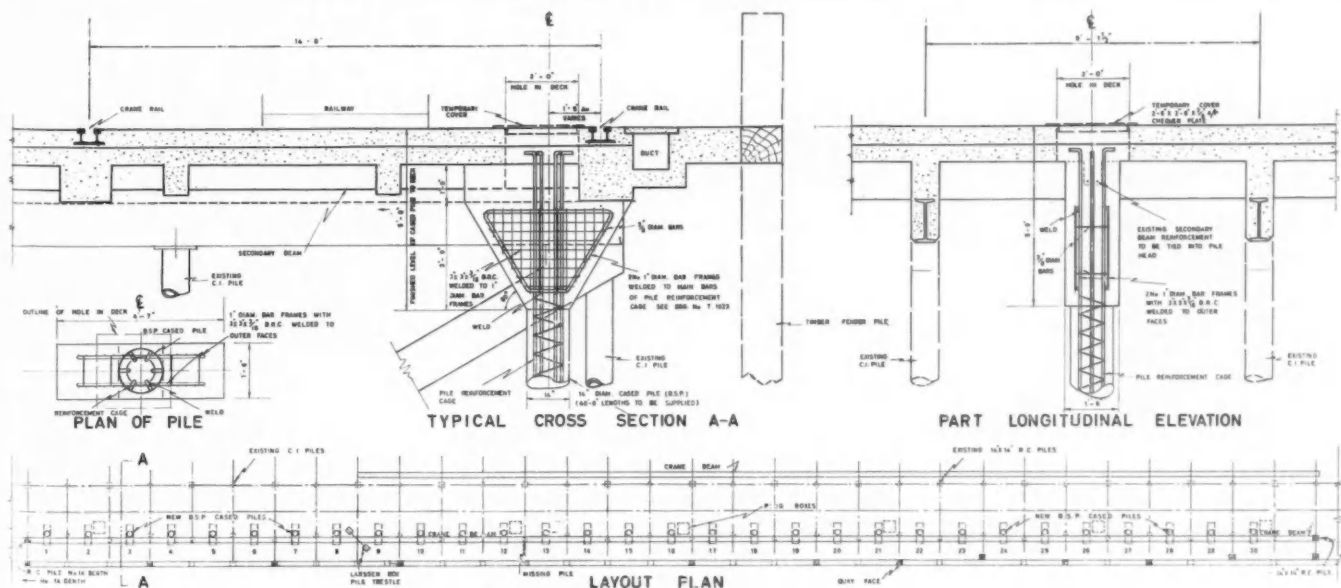
The positions of the new piles were set out on the deck and holes about 20-in. square were opened up. These were then covered with temporary square chequered plates, with stiffening ribs welded on, the ribs also serving as stops to prevent side movement of the plates. A special driving rig was welded up from angle sections. This took the form of four angles as leaders suitably spaced and supported on a trestle



Welded leaders being lowered into position through hole in jetty deck. Note chequer plates over other holes in foreground and pile hammer (on right) hung from 19 R.B. free barrel crane.

which could be secured by tee bolts to the existing railway and crane track. For ease of pitching, the greater part of this frame was below the deck level, only enough being above deck to ensure correct alignment of extension lengths to the casings.

The piles were pitched by the 3 ton wharf cranes normally part of the Town Quay equipment and owing to their lightness (about 18-cwt. each) the piles when first lowered actually floated at high tide. Before driving, about two feet of (literally) dry concrete was placed in the pile base as



Additional Piling to No. 13 Berth, Town Quay, Southampton.

Repiling a Jetty—continued



Grouting pipes indicating spacing of new piles. Nearest one connected to grouting plant.



Grouting plant for mixing and pumping colloidal grout. Grouting pipes in left foreground.

a driving plug. The internal driving hammer was a 2-ton cylinder of cast iron rather like an enormous sash weight, this was operated by a No. 19 R.B. free barrel crane, the drop being 4-ft. A No. K.L. 44 mobile crane was also available for general use on the job for handling the welded leaders and such purposes.

The driving of the 45-ft. casings proved at first to be only too easy as the anticipated hard stratum did not materialise and to drive to test depths one 45-ft. pile was cannibalised to provide extension lengths of 10 and 15-ft. The first piles were lengthened to 55-ft. and driving continued. Hard ground was found for the greater

part of the job at about 57-ft. below deck level and most of the piles were driven to a set of about 5 blows per inch or better to this depth. In the centre of the berth, a few piles had to be further extended to 60-ft. Such irregularities are to be expected in the Southampton Water area and the type of pile chosen was thus fully justified for this reason alone.

All driving was done at periods of slack traffic and at no time was it necessary to divert shipping to other berths. As the extension lengths were required at short notice, it was found necessary to use a smaller gauge for these owing to immediate availability. No. 9 gauge (0.144-in.) was used and proved entirely satisfactory. One rather surprising effect occurred during driving the extensions when on three occasions an extended pile met an obstruction during driving and the welded joint fractured with a loud report. The extension was in each case under no lateral restraint and it would appear most likely that a shock wave travelled up the casing to fracture the tube at the weld. One such failure occurred three times and the casing finally was reinforced with a 2-in. band of the same gauge.

The steel casing after driving was filled in the length below sea bottom with plain concrete, experience having shown that the casing will there be preserved from serious corrosion and will thus provide reinforcement. The upper part of the casing was considered as expendable and a cage of reinforcement was placed in the normal manner to form a reinforced concrete column of the upper part of the pile. This was then connected to the existing deck and beam structure by a haunching of reinforced concrete which also filled in the holes cut for driving the piles.



Welding on a ten foot extension to 45-ft. pile casing.



Welded leaders fixed in position with tee bolts in rail tracks.

Repiling a Jetty—continued



Reinforcement of cap fixed to top of concrete filled shell. Before placing of formwork.

The grouting was carried out with plant hired from Millar's Machinery Co. Ltd., the concessionaires for the Intrusive Prepakt system in Europe who also provided the necessary skilled supervisory staff. The plant, all electrically driven from the local A.C. supply, consisted of a mixer, agitator, and pump. The mixer produced the grout in a colloidal form consisting of sand, fly ash, and portland cement in the following proportions:—

200 lbs. sand. 45 lbs. fly ash.
112 lbs. cement.

Water was added from a graduated tank and with this was mixed a proprietary additive "Intrusion Aid." This additive is not only a wetting agent, but also imparts properties to the grout which transform it to a colloidal mix having a water repellent character. There is also a proportion of aluminium in the additive which, with the presence of the fly ash, reduces the setting rate and the early shrinkage.

Grouting pipes of 1½-in. diameter were prepared and placed in the piles after the reinforcement, but before the aggregate; nine such pipes were prepared in order that aggregate placing could keep ahead of grouting and these were made up in 5-ft. lengths so that they could be shortened as required during the grouting operation. In the event, 10-ft. lengths would have been better as, not only was it found that the grout travelled well, but also that the pipe sockets proved a hindrance to the extraction of the grout pipes. Each grouting pipe was provided with a pair of lifting eyes at

the top section for the attachment of shackles and the crane hook.

The aggregate first used was a seaborne gravel dredged from the west of the Isle of Wight. This is the principal local source of aggregate and it is screened after washing, the required grading then being reconstituted. The British Standard single size of 1½-in. consists of material between 1½-in. and ¾-in., with a small tolerance of smaller sizes. Trouble was experienced owing to the first six piles being filled with a substandard delivery which contained about 10 per cent or more of sizes below ¾-in. This was sufficient to fill many of the voids and to raise the specific surface of the aggregate thus increasing surface friction on the grout. The effect of this was to increase the pumping pressure needed from about 25 pounds per square inch to over 100 pounds. In spite of this difficulty, the grout travelled well up the pile casings and the grouting pipes were progressively lifted and shortened.

It was originally intended to fill the shuttering to deck level with the same grouted concrete, but owing to the initial difficulty with aggregate only two pile tops were done that way and the remainder were concreted with ready mixed concrete. The supply of aggregate from another source, which complied strictly with B.S. requirements, entirely cured the pumping trouble and with this material it would have been quite practicable to have used the colloidal grout concrete to deck level as originally intended. When the shuttering was struck from the two pile tops which were con-



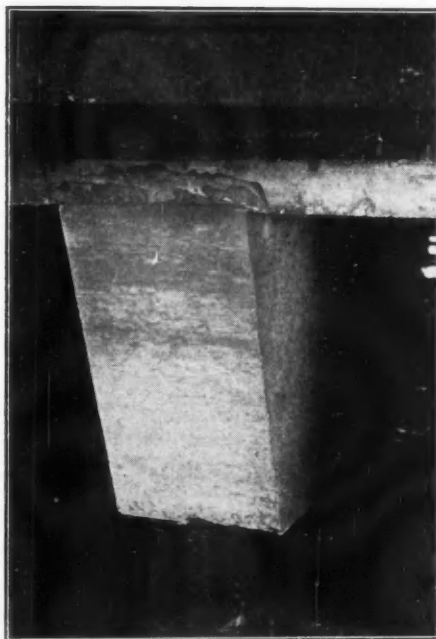
Shuttering of pile cap after completion of grouting process.

creted by grouting, the work was found on the whole to be of good quality and finish. The presence of the fine material had caused some segregation and a small layer of ungrouted sand about six square inches at the face. The pumping difficulty had also caused small voids at the extreme ends of the formwork. Neither of these defects would have occurred with suitable aggregate.

The actual grouting of each pile was done in about 20 minutes and towards the end of the job it was difficult to keep pace in the placing of dry aggregate.

Except for assistance by the grouting specialists the whole of the work was performed by the Works Department of the Southampton Harbour Board. With the exception of the grouting, no rigid programme was arranged so that operations could cease when traffic conditions dictated, which frequently happened. On such occasions, the personnel and most of the plant could be diverted to other work without inconvenience or any appreciable addition to the cost of the work. If the piling had been done with traditional methods, it is likely that the berth would have been closed for at least a month, with consequent interference with at least two other berths.

The cost of the work was approximately £125 per pile, which compares very favourably with any other method of doing the work. The saving of trouble and expense due to the avoidance of closing the berths, fully justifies the method adopted.



Cap to shell pile concreted by "Prepakt" Intrusive Grout method.

Repair and Maintenance Work in Civil Engineering

Heavy Annual Expenditure an Important Economic Problem*

In his address to the North Western Association of the Institution of Civil Engineers upon his appointment as Chairman for the 1959/1960 session, Mr. T. Whitley Moran, B.A., B.A.I., M.I.C.E., M.I.Struct.E., commented that the general field of repair and maintenance works in its broadest sense does not seem to have been covered previously by a paper or address to the Institution. He therefore proposed to deal with some aspects of this branch of civil engineering.

Giving a brief historical background to his address, Mr. Moran drew attention to the fact that the existing network of canals, roads, railways and harbours was substantially built between 1750 and 1900. Most of the water schemes, sewage works and gas works have been built since 1850 and the electric generating stations and motor roads are all relatively new. Thus it will be clear that there is to-day a vast quantity of engineering structures between 50 and 200 years old, which have to be maintained in serviceable condition and to be strengthened or rebuilt to meet present day requirements.

Prior to 1880, the materials of construction were earthwork, masonry, brickwork, cast iron and wrought iron. About 1880 mild steel began to replace cast iron and wrought iron and mass concrete began to replace masonry and brickwork. About 1900, reinforced concrete construction appeared and thereafter mild steel and reinforced concrete gradually ousted masonry, brickwork and the irons on a wide range of structures.

This resulted in several developments: (a) Structural Engineering became an important branch of Civil Engineering, (b) Industrial structures were now predominantly built of steel and reinforced concrete instead of brickwork as previously, (c) Industrial construction has largely been transferred from the building industry to civil engineering, (d) The volume of industrial construction is now roughly equal to that of public works, (e) As steel and reinforced concrete are not as durable as the materials that preceded them, a substantial maintenance problem has arisen.

Forty years ago there were virtually no specialist firms and the Public Works' Contractor tackled everything, piling of all kinds, reinforced concrete construction, ground cementation and water proofing work. There was no sub-letting. Scaffolding was done entirely with larch poles and there was no steel tubing. Mr. Moran had seen at first hand the rise of reinforced concrete construction; of many new forms of piling; of injection systems; and of a vast number of operations which were made possible by the introduction of portable air compressors. By 1958 there were about 70,000 men employed in specialist sections of Civil and Structural Engineering alone.

Some of these specialist processes are of great value in difficult cases of structural maintenance. For instance, we have pneumatic methods of piling and underpinning, cementation and chemical methods of strengthening foundations, pressure grouting for restoring the strength of masonry structures, and for sealing off leakage in reservoirs. We have a wide variety of waterproofing techniques, and a number of methods of repair using sprayed concrete coatings.

By such means as these, it is now possible to carry out satisfactory and permanent repairs in cases where, forty years ago, there was no alternative to complete reconstruction.

The Volume of Repair and Maintenance Work

Continuing, Mr. Moran said that for the first twenty years of his career, he had held two broad conceptions regarding civil engineering work as a whole; (1) That the construction of public works was much the largest sector, and that construction for the industry was of small consequence; (2) That new construction accounted for the vast bulk of the men employed and money expended, and that maintenance work was of negligible volume and importance.

He had since found that these conceptions were incorrect and proposed therefore to deal at some length with the second one relating to repair and maintenance work. By studying the official statistics issued during the past fifteen years, he has been able to derive some impressive figures which illustrate the heavy annual expenditure needed for repair and maintenance. In 1958, for instance, £650 million was spent on maintenance as compared with £1,570 million on all new work. This is a remarkable figure.

Furthermore, out of a total of about 1,400,000 men employed in the building and civil engineering industry in 1958, over 600,000 or 45% were occupied in repair and maintenance work.

It is important to mention that completely watertight figures are unobtainable, mainly because of the difficulty in defining what is maintenance. Many repair works include minor improvements or adaptations and it is clearly impossible to separate these. Hence the figures may be slightly overstated. On the other hand, when maintenance works cost appreciable sums, i.e., £50,000 to £100,000, they are frequently treated as capital works on financial grounds, and this probably is sufficient to adjust the overestimate referred to.

To ascertain what proportion of the £650 million might be spent on civil engineering work we can only work in proportion to the numbers of men employed, and we thus derive a figure of somewhere between £160 million and £200 million for the annual cost of maintaining our engineering structures and works.

To summarize, the annual bill for maintenance of all kinds is about £650 million, and the number of men engaged is about 620,000. Therefore, maintenance accounts for 30% of the total expenditure on construction, and for 45% of the total number of men in the industry. The disparity in the proportions is probably due to the fact that maintenance costs are chiefly labour and plant, with low usage of materials.

It is difficult to obtain exact correlation between the various tables published in official documents. The Board of Trade tables are based on the Census of Production, the Ministry of Works tables are based on the quarterly returns furnished by employers, while the Ministry of Labour and National Service figures are based on counts of insurance cards. Thus there is clearly room for marginal discrepancies, but in the broad outline there is no mistaking the general picture given by all three.

Thus building and civil engineering maintenance costs more

*Abstracts from the Address by the Chairman to the North Western Association of the Institution of Civil Engineers, October 1959.

Repair and Maintenance Work—continued

than the Health Service (£623 million) and more than current grants to Local Authorities (£639 million). The number of men is greater than the whole of Her Majesty's Armed Forces (590,000).

Few people realize the true state of affairs, as the annual bill for maintenance in any one undertaking may not be large. When the national figures are viewed in perspective, it becomes clear that maintenance of our fixed assets is a heavy toll on our labour force and on the national economy, and it is important to see that none of this effort is wasted.

In the light of these figures, what we need is a new outlook on repair work. For instance, do we allot to repair work a highly trained professional staff on the lines of the National Health Service, which is backed by the whole weight of the medical profession? Or of the officer staff of the Armed Forces? Is the expenditure scrutinized on the lines of the Budget in one of our great cities?

Alternatively, when designing structures, do we pay enough attention to durability? Do we try to evolve methods of construction which minimize deterioration?

Again, when repairing defects, do we aim at a temporary repair which will last say five years or so, or do we aim at a once-for-all cure?

To take another line of thought, does the Institution of Civil Engineers devote enough attention to deterioration, its causes, prevention and cure? Undoubtedly a number of valuable Papers have been delivered since the war on subjects which included maintenance problems on railways, roads, bridges, maritime works and foundations, but is the number of such Papers in any way proportionate to the scale of national expenditure or the number of men employed?

On the educational aspect, are we doing anything to prepare students in universities or technical colleges or student members in the Institution to face and solve the problems which many of them will encounter in the course of their normal duties?

Mr. Moran said that he did not propose to try and answer any of these questions, but clearly the issues are important. It is not that maintenance work employs one-tenth or one-fifth of our labour force, but that it employs nearly half the force. If maintenance work could be appreciably reduced, there would be a marked saving in man power.

Modern structures do not seem to be as durable as those built 200 or even 100 years ago. Have we really learned how to construct steel and reinforced concrete bridges to last for one or two centuries? One large reinforced concrete bridge in Scotland needed complete re-surfacing after a mere twenty years, and the same applies to many smaller ones. How can one contemplate the possibility that some of our fine modern structures might have to be re-faced throughout within our lifetime?

A railway engineer once remarked that no one should be allowed to design a railway structure until he had had seven years' experience of maintenance work. That is an arresting thought.

The Scientific Approach to Repair Work

Having shown how high the annual expenditure on repair and maintenance work really is, Mr. Moran said that he would now indicate how to make a radical approach to individual problems.

He was constantly meeting with cases where structural defects have arisen; where the cause was not identified at the beginning, and the wrong remedy applied. As a result, the structure deteriorated further, and eventually a major repair was needed. It is therefore essential at the outset to diagnose the trouble correctly. Without this the correct remedy may not be applied.

The normal repair scheme should satisfy two requirements. It should make good the damage which has already occurred, and

it should prevent that type of damage occurring again. It is probably fair to say that nine out of ten schemes meet the first requirement only. In fact most people look upon maintenance as a continuing operation, not as a once-for-all cure, and for that reason, maintenance work is never-ending.

Repairing the damage is really only a matter of making good. Preventing its recurrence uncovers a fresh set of considerations, and that is where the diagnosis becomes so important.

To begin with, it is necessary to ascertain the basic cause of the deterioration or failure. This is seldom easy. It entails a close examination of the visible defects. These are often only symptoms of the real trouble, and it is essential to distinguish between symptoms and causes. For instance, cracks are not defects, they are results, the symptoms of defects. The more care that is devoted to this stage of the investigation, the more likely it is that a permanent cure will be evolved. Defects in a structure may arise from three main groups of causes.

- (1) Bad construction (poor workmanship and poor materials). This is commonly thought to be the normal cause, but this is not borne out by experience.
- (2) Unsuitable design. This is a far commoner cause than is generally supposed, for instance in the amount of cover allowed for in reinforced concrete work, or in failure to allow for poor foundation conditions.
- (3) Onerous conditions of usage, for instance the presence of deleterious fumes, chemicals, steam, etc., or periodic overloading.

Preliminary Investigations

In anything other than a simple and straightforward case, it is advisable to ascertain the date of construction, as the type of design used at that particular period may throw some light on the failure. For instance the various methods of constructing service reservoirs 60 or 80 years ago differ widely from those used today.

If drawings are available they should be studied closely for possible weaknesses, but they must not be relied upon too much. Changes in design may not have been recorded, supervision may have been slack, and the work scamped. It is a common experience to find 6-in. of concrete where 12-in. is shown on the drawing. Thus it is important to check the accuracy of the drawings, for instance by probing in soft ground, or by punching inspection holes with a pneumatic drill, or by cutting through the surface to expose the hearting. It is extraordinary how few people think of doing this.

When dealing with problems of settlement, it is vital to ascertain the surface geology, not merely of the site itself, but also of its immediate surroundings. Sometimes a great deal of information can be obtained very simply by taking a grid of borings with a 3-in. ground auger and plotting up the results. When the structure is then plotted on the sections, the nature of the trouble may become obvious.

In Mr. Moran's view, engineering geology is a more fundamental subject than soil mechanics. Very few engineers have an adequate working knowledge of surface geology, and the ground conditions likely to be found even in their own area remain a mystery to them. Geology and soil mechanics are complementary. Geology is qualitative and soil mechanics quantitative. It is often possible to make a quicker appraisal of the site by geology alone than by soil mechanics alone.

Turning to structures, all stress cracks should be noted and every effort should be made to distinguish between shrinkage cracks, settlement cracks and movements due to expansion or to uplift. Cases of chemical attack on concrete require the closest investigation and samples of the affected material should be sent to a cement laboratory for testing and report.

Repair and Maintenance Work—continued

It is very valuable to take photos of a structure and it is better to take too many than too few. The most informative ones should be enlarged. In addition to taking close-up views, always take a few with the structure in the middle distance so that its surroundings may be studied at leisure.

It will be appreciated at once that detailed investigations of the type described are in fact very rarely undertaken, but they do not take long and they produce a great deal of information. This method of approach is in sharp contrast to the very common one of sending out an inspector or clerk of works to make a report, in which case it is highly likely that only the obvious surface symptoms will be observed, and the ultimate cause of the damage overlooked.

Diagnosis

When the preliminary investigation is complete, the next step is to correlate all the information obtained. Sketches or drawings should be used to record the foundation features, where these are of importance, and all stress cracks. It is most important that all such sketches should be true to scale, otherwise they may mislead. Photos should be arranged in a definite sequence, accompanied by a key plan.

The process of deduction then commences, on the parallel of a doctor diagnosing a patient's disease, or of a detective reconstructing a crime from the observed evidence. The medical parallel is perhaps the better one, as many types of engineering structures are prone to clearly defined classes of deterioration. Some can be diagnosed almost at sight, others are most obscure and can easily be mistaken for something else having similar symptoms. Correct diagnosis of the true and ultimate cause of the defects is of critical importance. Anyone can make good the visible damage. Without an accurate diagnosis, it is impossible to remove the cause and prevent the trouble recurring.

There is hardly any published information available to assist in this stage, and the engineer must be prepared to work from first principles. Indeed it is better that he should do so. An elementary resolution of the forces which are acting may throw up the answer more quickly than a check on the design.

The process is an analytical one, because the practitioner is working back from observed evidence to ascertain the case history. Of course these methods are basically comparable with those used by the Building Research Station and Road Research Laboratory and similar bodies, although evolved independently.

In contrast, many organizations regard maintenance as the Cinderella of engineering work. Repair work is often delegated to junior members of the staff or to a foreman bricklayer. There is no proper investigation and repairs are applied, by some rule-of-thumb method, which last five years. This may be repeated indefinitely and there are innumerable cases of cumulative waste of money and waste of labour.

Formulation of Repair Methods

If a repair problem is approached systematically and the ultimate cause of failure is identified, the next step is to consider how the root cause can be permanently rectified. Usually there are several alternatives, and the problem is then reduced to making a choice of the expedients available.

Occasionally it is necessary to add structural strength to the structure and here we have hardly any published material to guide us. In the limited case of water retaining structures, the water stresses are finite and can readily be calculated. In the majority of cases, however, there is no simple method of determining the residual strength of the structure and it becomes necessary to find some alternative line of approach to the problem. One valuable expedient here is to assume that the structure is on the point of falling down, and then design to provide a

factor of safety against collapse. The calculations then become finite and straightforward. Whatever residual strength remains in the structure may be allowed for by designing the added work with a factor of safety less than that used in normal design.

It should be made clear that design expedients like those involve a totally different mental attitude—and perhaps a more fundamental approach—to that obtaining in conventional design work. Seen in perspective, it is an art rather than a science.

Execution

Having selected the most expedient repair, it remains to put it into execution. Many cases are quite straightforward but there are the exceptional cases which involve strengthening a structure which is under load. Here it is necessary to evolve a method of doing work by stages in such a way as to uphold the basis of design. This may involve primary and secondary strutting, or jacking to a predetermined load, and the site procedure may become elaborate. The problem is entirely different in kind from building a new structure on an open site.

One very remarkable feature of such works is that they normally do not cost a great deal more than the sort of temporary making-good which lasts five years. Furthermore, they usually cost a small fraction of the cost of demolition and reconstruction.

Something should be said about the contractual aspect of remedial works. In far too many cases, the work of repair is looked on predominantly as a contractual operation and the engineering considerations drop into the background. Many pages of special conditions of contract are prepared, whilst the specification is limited to one or two sheets, which describe how to make good the visible damage without removing the cause.

Repair operations require skilled workmanship and entail specially trained foremen and operators. What is not so widely recognized is that they also call for specially trained engineers—men who can see beyond the technique and visualize the work as an exercise in engineering surgery.

If we are ever to reduce the national bill for maintenance and effect savings in the labour force, it will be necessary to make a completely new approach to the whole matter.

Coaling Appliances at Immingham

New High-Speed Shipping Plants Installed

Two new coal-shipping plants of novel design, each capable of automatically unloading coal from railway wagons and transferring it to a ship's hold at a rate of up to 1,350 tons an hour, have been installed by British Transport Docks at the Port of Immingham, Lincolnshire. They were designed and constructed by Mitchell Engineering Ltd., of Peterborough in conjunction with the British Transport Commission's dock engineers. The civil engineering work was carried out by A. Monk & Co. Ltd., Warrington.

Both appliances can handle 55 wagons of coal an hour, the tonnage varying with the size of the wagons which range from 10 to 24½-ton capacity. In a recent trial one plant shipped a cargo of 17,500 tons of washed small coal from small capacity wagons aboard the Norwegian bulk cargo vessel, m.v. "Providence", in the record time of 29½ hours at an average rate of 600 tons an hour.

Technical Description of Plant

The two plants are installed 400-ft. apart on the South Quay. Each appliance consists of the following:—

1. Wagon haulage mule and placer
2. Wagon tippler and hopper

Coaling Appliances at Immingham—continued

3. Apron plate feeder from tippler hopper
4. Belt conveyors to loading tower
5. Loading tower feeding to ships' holds.

All these separate items are electrically driven and interconnected to work in conjunction with each other, and all movements are overlapped so that a continuous flow of coal is maintained to ships' holds without loss of time.

The wagon handling plant comprises a haulage mule furnished with a hook to engage the coal wagon haulage chain. The mule runs on its own track situated between the wagon tracks and is hauled up and down an inclined gantry by steel wire ropes attached to an electric winding winch situated underneath the gantry. Both tracks run up the reinforced concrete gantry at a slope of 1 in 4 to a high-level platform where the wagon tippler is situated.

The wagons are marshalled on the sidings at the lower end of the inclined gantry and gravitate to a predetermined position at the foot of the incline.



A panoramic view of the first plant to be completed showing a wagon on the tippler.

The mule, which is normally housed at the top of the incline, is set in motion by the plant operator pressing a "start" button in the electrical control system. The sequence of operations thereafter is entirely automatic and continues until the operator presses the "stop" button.

The mule, when started, travels down the inclined track, passes under the wagon standing at the bottom of the incline, and after a short pause, reverses, engages with the wagon chain and hauls the wagon up the incline on to the platform and stops adjacent to the wagon tippler.

Just before the mule comes to rest the placer is set in motion. This runs on a separate track alongside the wagon track on the platform at the top of the incline, and is hauled to and fro by steel wire ropes attached to a separate winding winch. It is provided with a folding arm which is automatically raised at starting to engage with one of the rear wagon buffers.

The placer, after pushing the wagon forward on to the tippler cradle thereby disengaging the wagon chain from the mule, stops and returns to its starting position ready to receive the next wagon, lowering the folding arm en route.

Immediately the placer has taken charge of the wagon the mule starts on its return journey to the bottom of the incline to pick up the next wagon.

As soon as the placer starts on its return journey the tippler, driven by an electric motor through rack and pinion gearing, elevates the wagon and tips the coal into a hopper. After a brief pause to allow the wagon to empty completely it is returned

to its original position. By this time the next wagon has reached the top of the incline and is moved forward by the placer, pushing the empty wagon off the tippler cradle and taking its place ready for tipping.

The empty wagon runs away down an incline to a rising ramp, comes to rest and reverses back to catch points where it is diverted to a falling gradient and returns to sidings level.

The coal is discharged from the tippler hopper by means of an apron plate feeder driven by an electric motor which in turn delivers it to the belt conveyor in the loading tower. The rate of feed can be adjusted by means of a rack and pinion gate so that a steady flow of coal is maintained.

The belt conveyor transports the coal in a stream up the loading tower on to the adjustable boom for discharging into ships holds.

The boom is telescopic and can be extended from its housed position behind the face of the quay wall to its fully extended position to reach the further side of the ship's hold. In addition, the boom can also be lifted and lowered to suit the height of the ship above the water line and the difference in level as the ship settles during loading.

As well as these movements the whole tower structure is mounted on a radial rail track at the quayside and supported on a swivelling pintle at the rear end so the boom may be travelled for and aft over the ship's hold. By a combination of all movements every part of the hold can be reached.

The belt conveyor, boom lifting, boom telescoping, and travelling are driven by separate motors.

The wagon haulage, placer and tippler are controlled by one operator housed in a raised cabin on the elevated gantry adjacent to the tippler. From this position a clear view is obtained of all these operations. The apron plate feeder, belt conveyor, boom lifting, and telescoping motions and slewing of the tower is controlled by a second operator housed in a cabin mounted in an elevated position on the tower structure. The cabin is placed so as to afford a complete view of the ships holds, and surrounding gear.

The two operators between them control every movement of the plant and are in telephonic communication with each other, and also with the wagon marshalling operators at the foot of the inclined gantry. Once set in motion the plant works entirely automatically until stopped.

The electric control gear, however, is so arranged that each motion can be operated separately by hand when desired, as when testing. The conveyor and feeder can be run at half speed when required, for example, for filling ships bunkers, or "topping-up" holds.

The leading dimensions, and other technical particulars are as follows:—

Length of plant from foot of gantry to quay face	350-ft. approximately
Boom extension beyond quay face	60-ft. maximum 10-ft. minimum
Height of boom above quay level	60-ft. maximum 5-ft. minimum
Range of slewing at max. extension	130-ft.
Speed of boom lifting at head	20-ft. per minute
Speed of boom telescoping	20-ft. per minute
Speed of boom slewing	30-ft. per minute
Conveyor belt width	60-in.
Conveyor belt speed	400/200-ft. per minute
Tippler cycle	40 seconds
Mule haulage speed	240-ft. per minute
Mule return speed	480-ft. per minute
Placer speed	180-ft. per minute

A Modular System of Loading Cars.

Successful Experiment at the Port of Dunkirk

(Specially Contributed)

The problem of shipping motor cars, in spite of fifty years of experience, has not yet been solved. Despite the many different methods used and the wide variety of gear employed there are two facts about this traffic that refuse to be ignored. Every improvement in the design and finish of the motor car has made it, in its unprotected condition, increasingly liable to damage during its many handlings. Given this extreme vulnerability how is the shop window finish to be preserved, seeing that the holds of dry cargo ships have not even a regular or standard shape?

The practical solution to the problem has been attempted on two separate lines. The first one accepts the awkwardness inherent in a car on its own wheels, but argues that the nearer the conditions in the ship's hold resemble those in the garage, the greater the number of cars that can be carried in safety. Hence the interesting experiments that have been made of inserting temporary decks, generally in the largest holds. Early attempts to provide mezzanine floors, or additional tween decks, took the form of fairly heavy wooden structures on substantial columns, rising from the ceiling. Later developments utilised light metal in place of timber (it was claimed that return cargoes of self-trimming bulk such as grain and certain ores would "run through" the perforated, or slotted metal decks, making it unnecessary to dismantle them). Metal sections that can be pivoted from the interior wall of the hold, making large ledges on which cars can be stowed, is a recent innovation.

The second solution stems from a refusal to accept the "awkwardness" that prompted the series of false decks. However many protuberances have come to be embodied in the modern car, says the second school of thought, it can still be turned into a rectangular package, and can be treated as such by the stevedore, provided it is placed in a simple but substantial casing. Not the cumbersome wooden package that in the 1920's enclosed the primitive car, first shorn of its wheels and wings, but a slatted crate, economical to produce and if not expendable, capable of being collapsed for the return voyage. As in the case of the multi-tween deck, car crates have been made of wood, tubular scaffolding and channel steel.

Naturally the job of stowing cars for export is greatly simplified when only one design is concerned. It has been the variety in overall dimensions presented by a mixed shipment of cars that has made the pre-planning of the valuable cargo space so difficult. It is not made easier by the fact that the "cubic" in each hold is different and again, that, in the absence of a standard dry cargo carrier, the total cubic in each ship varies.

The m.v. "Arvidsjaur" which recently loaded motor cars from Dunkirk for New York has attracted much interest in shipping and port circles because she carried cars of one design only (Peugeot 403) and because she is one of a line of ore and coal carriers (owned by Grängesberg-Oxelösund of Stockholm, English agents Hull, Blyth and Co. Ltd. of London) which are of a standard size and design. Thus the pre-planning got off to an excellent start.

The "Arvidsjaur" is about 14,500 tons capacity and 600-ft. long; she has no tween decks and a continuous lower hold forward, with three single action large hatches (gearless) and high coamings. To facilitate trimming of bulk cargoes the sides of the holds break at an angle of about 40 degrees to the ceiling; owing to the extreme size of the hatches much of the hold is under plumb.

The approach made by the shipping company was entirely one



Fig. 1



Fig. 2



Fig. 3

of logistics—almost, in fact, a military operation. It was very sensibly realised that not all the problems could be solved on the drawing board and this was indeed found to be so during the actual loading. It was obvious however that the crated method would be the more likely to give good results.

Each crate has been designed to take one car (see Fig 1); in fact it is tailor made for the Peugeot 403. No doubt smaller cars of the approximate wheel base could be carried in these crates with some loss of space, but certainly they would be unsuitable for cars of a larger type. A single crate consists of two main fore-and-aft members made of channel steel and into these fit the car wheels. The operation of crating consists of pushing the

A System of Loading Cars—continued

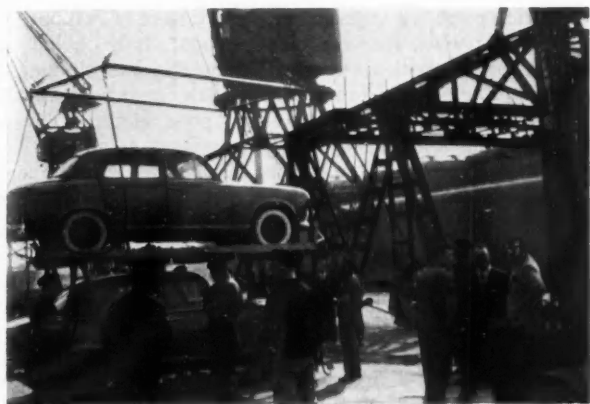


Fig. 4



Fig. 5



Fig. 6

car by hand from the quay, up a wooden ramp of similar gauge (and about 4-in. high) and of aligning it carefully so that the metal "chairs" that hold the wheels in position can be tautly fixed, the door handles do not protrude over the plumb of the crate and neither are they fouled by the side members.

These side members consist of two inverted "V" frames, one forward and one aft. Their purpose is to give protection to the enclosed car and to take the weight of a crate, or crates, piled on top. Each "V" frame consists of two members, which mitre together at a fairly acute angle, the joint being made by an overlapping flange, made fast by a simple tie bolt that can easily be knocked out when the crate is dismantled (see Fig. 1). Each

of the two members of the "V" frame moves in an arc for fixing in position and for collapsing; the bush at the heel of each is looked after by nipple greaser. On the connecting flange, midway between the tie bolt and the ends, are two small inverted "V's" which take the weight of the crate piled on top. In addition to the wheel toggles the two metal "boxes", which are to be found on a level with the erstwhile running board and which are used to jack up the car, have been utilised as additional securing points. A thin metal bar is introduced into the open end of the box and this is made fast by a wire to an eye in the wheel channel (see Fig. 2).

Running "thwartship" and under the crate are two inverted metal channels into which the forks of a forklift truck can be inserted (see Fig. 3). All horizontal movement of the crated car is done by forklift truck and this applies within the hold of the ship also. So that the forklift truck can place a crate on top of another with precision, two "V" channels are welded on the underside of each fore-and-aft main channel. Into the aperture formed by these, fits the horizontal bar (with the flange duly bolted) of the "V" frame of the lower crate (see Fig. 4). This simple guide certainly ensures that within the hold the ends of all crates are flush and this essential result is achieved at the first attempt.

How then are the crates, precisely designed as they have been, stowed in the ship so that it has been estimated that the waste space across the hold can, for each tier, be reckoned in millimetres? It was impossible to accept the considerable loss of space that would result from the self-trimming "break" on to the ceiling. Fig. 5 shows how the difficulty has been overcome. Triangular metal brackets (which can be removed for the return voyage), two to each crate, span the angle caused by the break from the vertical. This "console" (the name given to each pair of brackets) is exactly the height of a crate so that a tier of three crates placed on a console matches exactly the tier of four crates placed on the ceiling alongside. Apart from the two wing tiers there are seven tiers across the hold. So carefully has the modular principle been studied that the sum of the widths of the nine crates is said to be only 30 mm. less than the inside measurement of the hold. This was intentional so as to avoid any lateral movement during the voyage.

Two further points require attention. Firstly, it has been rightly argued by those planning the traffic that the strain on each crate varies with its vertical position in the ship. There is not therefore any need to build them of a uniform type. Three kinds of crates have been designed and to simplify handling, each has been painted a different colour. Capable of taking the weight of three loaded crates (the total tier weight of four cars and crates is 5/6 tons) is the red type, followed by the green, a lighter crate. Obviously the top crate (yellow) is only a means of retaining the car in position so there is no call for more than the base channel bars. The simplicity of the yellow crate can be clearly seen in Fig. 6.

In spite of the extremely favourable conditions for loading, as compared with those on a general dry cargo carrier, not all the "cubic" was get-atable by the quay crane. The wing stowage was done by forklift truck; the final tiers directly under plumb were, of course, completed by the crane which had previously taken out the forklift truck. It was the space lying directly under the central deck island separating each hold, that could not be plumbed; neither was there headroom enough for the crates to be swung into position. Just as two cranes can make an acceptable lift by the Yo-Yo principle so it was found that two forklift trucks, each working from the limits of the adjacent holds, could make a Yo-Yo lift. Although the operation was made most difficult by the limited vision of the truck driver, it was

(concluded at foot of following page)

Correspondence

To the Editor of "The Dock and Harbour Authority."

Dear Sir,

Unprotected Cargo

May I seek the good offices of your Journal to ventilate a matter which must be of considerable concern to the exporters and importers of certain classes of merchandise which generally do not lend themselves to fully-protected packaging and, being subject to damage by rough handling, incorrect slinging, unsuitable stowage and the like, are classified accordingly as goods unprotected or insufficiently packed and consequently are liable to attract claims quite distinct from those arising from shortages, pilferage or contamination.

When dealing with claims I have always considered the procedure of each interested party doing its utmost to disclaim responsibility and place it elsewhere as most unsatisfactory, though scarcely surprising under existing conditions and with so many conflicting reports as to where damage may have occurred. One can become very adept at refuting liability particularly so when backed up by the conditions governing a Bill of Lading or a formidable set of Port By-Laws or Regulations. Underwriters must also be interested in the outcome of such disputes for the acceptance of liability by any one party can possibly pave the way for a counter claim.

Without going into too much detail, I think the cycle of events between manufacturer and consignee can be itemised as given below:

- (a) Manufacturer, supplier or shipper to place of reception and point of rest at the loading berth.
- (b) The movement and method used in transporting to ship's or crane hook.
- (c) The arrangement for slinging and hoisting.
- (d) The landing of the set and conveyance to point of stowage.
- (e) Protection given in the way of dunnage, mats, etc. and the suitability of other cargo stowed in close proximity.
- (f) The voyage, with consideration to weather, and cargo loaded or off-loaded en route.
- (g) Discharging, method of handling and slinging; landing on to the wharf and means of conveyance to stacking site and method of stacking.
- (h) The delivery, transport and off-loading and stacking at consignee's store.
- (i) The additional handling invariably incurred when moving goods by lighter or rail and the special circumstances relating to transshipment cargo.

At one point or another along this conveyor line, damage may be incurred which could possibly have been avoided, and the further along the line the more difficult it is to determine at what

point it did occur. The very fact that goods are accepted under an unprotected clause, or insufficiently packed, etc. can result in them being admitted without the same degree of responsibility as would apply when receiving other goods. It is obvious that in some respects, particularly in the handling and slinging, the reverse should apply and the fact that such cargo be branded as unprotected and possibly treated as the "poor relation" in regard to freight should have no bearing on the issue at all.

I have been present at numerous discussions with Importers and Shipping Agents when they have expressed the greatest concern in regard to a rising trend in breakages with a corresponding increase in insurance rates. One can scarcely criticise the Insurance Companies for adjusting rates to cope with increased damage, but in principle it is wrong that the problem should have to be approached in this way.

I can recall an occasion of a vessel breaking bulk when I actually sighted hundreds of asbestos sheets stowed in the square of the hatch largely ruined, for they had obviously been slung in sets with a bare wire sling which had bitten well into the edges of the sheets in addition to causing numerous fractures. In places, the grease from the wire and the impression from the lay of the wire strands remained visible. I also recall incidents where cargo has been placed at the disposal of the consignee in perfect condition but arrived at the consignee's warehouse considerably damaged by sheer negligence during the last lap of the journey.

Such individual cases pin down liability but generally speaking this is not possible with any certainty and in any case, the determining of liability should be of secondary consideration to finding a way to prevent or minimise such damage during the process of conveyance.

I am not sure there is a wholly satisfactory answer to the problem, at least not without incurring such a heavy expenditure that it would defeat the purpose, but what I do think is possible, and could lead to constructive results, and which is the purpose of my letter, is for an impartial and experienced observer to be occasionally engaged to follow and to report on a particular consignment throughout the period of conveyance.

It seems possible there may be a number of ways in which this could be arranged. One way would be for a Shipper or an Insurance Company to arrange for an independent confidential report, or possibly a joint report. Alternatively, the confidential nature could be dispensed with in so far as it being known that an observer was holding a watching brief and so attaining an extremely valuable psychological alertness by those concerned, the report, of course, remaining confidential to the employer.

In my opinion, however, by far the best method would be for the report to be confined to not more than two parties and let it be no secret that a particular shipper or Insurance Company is arranging for an impartial and independent report on a particular consignment. It would be good policy if the Shipping Company were advised of the intention and their co-operation requested; for the purpose of the mission is not necessarily to find fault, but to reduce damage.

When this is known, it seems reasonable to assume that Shipping Companies would make particular mention through Agents, Port Authorities, Ships Personnel, Stevedores, Master Porters, etc. to ensure careful handling of the particular consignment and if, by so doing, this will result in an improved outcome the report would be of secondary consideration to the result. I do not suggest, however, that any such procedure should be uniform in respect of any one particular trade or shipping company. I think the uncertainty of the project is a valuable asset and that too many observation reports would be unnecessary expenditure and do more harm than good.

Yours faithfully,

P.O. Box 150,

Tema, Ghana.

12th September, 1960.

F. E. BROADHURST,

Port Manager.

A System of Loading Cars

(concluded from previous page)

successfully done and illustrated the wisdom of not attempting to settle all the practical difficulties on the drawing board.

The initial voyage of the "Arvidsjaur" with cars was intended as an experiment. Actually 168 cars were crated and 32 were loaded in the conventional way with timber dunnaging, on the steel hatch covers.

Vessels owned by Grängesberg-Oxelösund load iron ore at Narvik for a U.K. port and load coal from Hampton Roads for Gothenburg. It is to fill the gap on the Atlantic leg that the car traffic is being developed. The crates are collapsible and can therefore be carried at little cost. One problem which will exercise the ingenuity of the company lies in determining the total number of crates required and their use-cycle, so that, given a flow of cars of the designed type, there will always be sufficient at Dunkirk at the times when they are wanted.

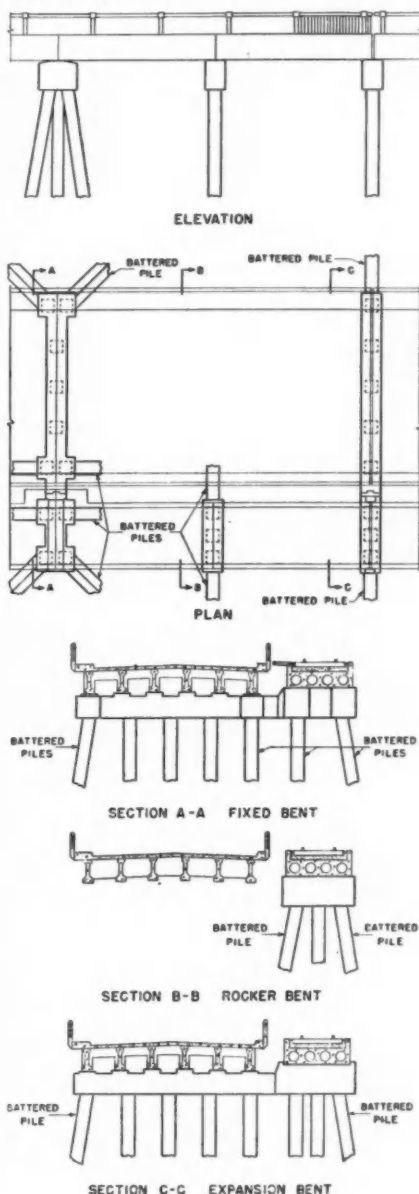
Pelican Island Causeway, Galveston, Texas

With the opening of the Pelican Island Causeway early in 1958, the City of Galveston, Texas acquired access to approximately four thousand acres of land. This acreage has been available for industrial and municipal development by filling operations which are nearing completion. Unlike most Texas communities, which have had adequate space for expansion, Galveston has experienced a shortage of property for many years. Residential, commercial and industrial developments on Galveston Island had used most of its suitable land when it was decided to construct the bridge which will make possible the improvement of the virtually uninhabited, 4,000-acre Pelican Island, situated directly north of Galveston, across the relatively narrow ship channel.

Late in 1954, the Galveston County Navigation District No. 1 retained a firm of Consulting Engineers to make preliminary field investigations, prepare contract plans and specifications and supervise construction of a combined highway, railroad and pedestrian bridge with a bascule span over the main ship channel and the necessary land approaches to connect 51st Street in Galveston with Pelican Island. The first construction contract was awarded within nine months. As work proceeded on the substructure, final designs were prepared for the superstructure and for the 1,552-ft. long viaduct over the railroad switching yards on the Galveston shore.

A chart prepared by the United States Coast and Geodetic Survey shows much of the area now occupied by Pelican Island under one to five feet of water in 1867. On this chart about a mile north of the Galveston waterfront appears a small island labelled "Pelican Spit," and about three-quarters of a mile north of that a larger land area, designated "Pelican Island." There is no indication that any material dredged from the Galveston Ship Channel had been dumped along the north bank of the channel prior to the publication of the chart. Reports by the Corps of Engineers dated 1900 and 1901, show some changes in the location of Pelican Island and Pelican Spit, indicating that both were sand bars, subject to shifting. Charts dated 1904 and 1907 show a narrow strip of exposed ground along the north side of the ship channel, joining the original "Pelican Spit" apparently produced by the dumping of material dredged from the channel. In succeeding years, this strip of exposed ground is observed to have become progressively wider, until it merged with the original Pelican Island about 1947.

Most of the portion of Pelican Island which is included in present development plans was created by the dumping of fill dredged from the channel. The elevation of the exposed ground near the ship channel is appreciably higher than on the rest of the island. Along the north bank of the channel, portions of the island have been leased to private industrial interests for the past 30 years, the largest development being that of the Todd Shipbuilding Company. Prior to the opening of the Pelican Island Causeway, the only access to the island was by ferry operated by this dry-dock firm.



The Pelican Island Causeway extends about 8,200-ft. from Avenue F, along 51st Street in Galveston, across the railroad switching yards and the Galveston Ship Channel to Pelican Island. In mid-channel, a 160-ft. long, single-leaf, rolling lift bascule span provides adequate clearances for all types of shipping. Flanking this span on the south side, are four 102-ft., steel girder spans, supported on concrete piers. A 1,000-ft. long prestressed concrete trestle, on concrete pile bents, connects the girder section with a hydraulic-fill embankment section which extends about 1,000-ft. from shore. North of the bascule pier, five similar steel girder spans carry the highway and railroad to the northern trestle section, which is about 1,100-ft. in length. The causeway terminates on Pelican Island with a 400-ft. long embankment section.

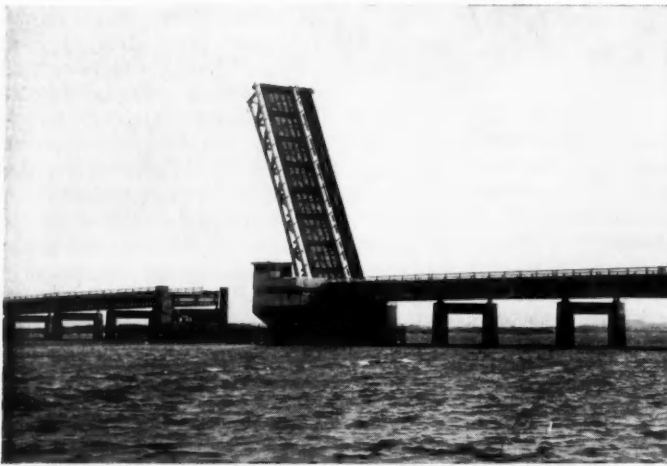
On the Galveston shore, the embankment section continues approximately 1,700-ft. inland, where the 1,522-ft. long 51st Street Viaduct begins. The prestressed concrete structure crosses seventeen railroad tracks to furnish direct vehicular access to the causeway from midtown Galveston. The causeway's rail track arises from grade to the embankment on a separate ramp on the north side of the switching yards.

The embankment section was constructed by the placement of hydraulic fill between toe walls constructed of pre-cast concrete sheet piles. These sheet piles, 15 x 30-in. in section and approximately 27-ft. long, were jetted and driven to grade. A reinforced concrete cap, cast in place on each wall, tied the piles together. The embankment was brought to grade with sand dredged from the bottom of the bay. The slope from the pile cap to the roadway elevation is paved with concrete to protect the fill against wave action.

Prestressed piles for the trestle substructure were cast at Pasadena, Texas, some 35 miles from the job, barged to the site and driven in place, without rehandling. Each pile was 24-in. square, having a hollow centre made by means of a 10-in. Sonovoid tube. Thirty $\frac{3}{8}$ -in. cables, prestressed to 12,000 pounds, were used in each pile. These piles were cast in 400-ft. long beds in lengths ranging from 50 to 94-ft. To speed production, the piles were steam cured. A retarding densifier was used in the mix for all structural members.

The concrete trestle sections consist of a unique combination of 50-ft. spans for the highway and 25-ft. spans for the railroad. The pile caps at the bents that are common to both highway and railroad superstructures were designed with vertical joints to permit unequal deflection of the two superstructures. Each simple bent is composed of five piles for the highway and three for the railroad, with the outside pile at each end battered to resist transverse

Pelican Island Causeway—continued



The single-leaf, rolling-lift bascule span over the main ship channel allows adequate passage for all types of shipping.



Aerial view of the entire project showing the 51st Street viaduct over the railroad switching yards in the foreground.

forces. Fixed supports have four battered and three vertical piles under the highway and four battered piles under the railroad. The four outside piles were battered diagonally, three of the interior piles were battered longitudinally. Bents under the railroad only are supported by three piles each, two of which are battered transversely. All battered piles were driven on a slope of 6 on 1. The concrete caps completing the bents were cast in place.

Each 50-ft. highway span has six prestressed concrete stringers, supporting a 6½-in. cast-in-place deck slab. The 25-ft. railroad spans are prestressed concrete slabs 10-ft. 6-in. wide and 2-ft. 8-in. thick, having four 20-in. diameter Sonovoids in each slab. The Pelican Island Causeway is the first major structure in the United States to employ these slabs for a rail crossing. All concrete superstructure members were fabricated in the same yard as the piles, transported to the site as needed, and erected by barge-mounted cranes.

For the girder span sections flanking the bascule span, each pier consists of two legs, built in separate cofferdams and joined 12-ft. above the water by a heavy concrete cap. Untreated wood piles, up to 75-ft. in length, were driven into the bottom of the bay inside the cofferdams. As many as 49 wood piles were used in a single pier. A 9-ft. thick tremie seal was poured and the cofferdam was unwatered. A distribution slab 4-ft. thick was placed over the tremie seal and the concrete pier leg was built. When the two legs of one pier had been completed, the heavy concrete cap was cast in place, completing the pier.

The bascule piers were constructed in similar fashion. For the south pier, which houses the machinery and supports the control house and the single leaf span in its open position, a 70 x 73-ft. cofferdam was built in 42-ft. of water. Before the 12-ft. thick tremie concrete seal was poured, 175

steel H-piles, about 55-ft. long, were driven into the bay bottom. Concrete for this 2,400 cubic yards pour was mixed in transit mixers on shore and transferred to large buckets carried on barges, self-powered by huge diesel outboard motors. Cranes working at the cofferdam lifted the buckets from the decks of the barges to the tremie hoppers. The pour was completed in 36 hours. When the tremie seal had been completed and cured, the cofferdam was unwatered and a 9-ft thick distribution slab was built on top of the tremie concrete. The rest of the pier was poured in two additional lifts. Construction of the smaller north bascule pier was done in the same manner.

The bascule span carries the two-lane roadway, the 3-ft. sidewalk and the single railroad track on a deck truss structure consisting of eight 20-ft. panels in the forward arm and two 16-ft. panels in the rear arm. These trusses are spaced at 38-ft. centres and have a minimum height of 14-ft. 6-in. The concrete counterweight was constructed around steel frames riveted to the trusses in the rear arm. A 5-in. deep open steel grating was used for the roadway floor, and the railroad track is supported on timber ties fastened to the stringers. Concrete brackets cantilevered out from the west face of the bascule pier support the control house and equipment room.

The bascule span rolls on two sets of track castings, one connected to the bottom of the trusses and the other embedded in the pier. Operating machinery is located between the trusses in front of the counterweight, and the rack and pinion are outside the trusses. Span locks are provided at the toe and heel of the bascule. Two 60 h.p. electric motors were installed to operate the span under normal conditions. In the event of power failure, a 25 horsepower motor will perform the work, at a slower speed, using energy furnished by a diesel-

electric generating unit. Sufficient power will be provided by this generator to operate the causeway's lighting system, traffic gates and roadway barriers, in addition to the bascule span, if necessary.

The 51st Street Viaduct consists of a concrete slab cast in place over prestressed concrete stringers. Most of the spans are 50-ft. in length, but there are three spans of 58-ft., and one 100-ft. span, also constructed of prestressed concrete. The substructure of the viaduct was constructed by driving five 24-in. square, prestressed piles for each pier. A cast-in-place concrete cap over these piles supports the concrete stringers. The spans which cross railroad tracks are supported at each end by a narrow solid concrete pier supported on timber piles. These piers were designed to provide maximum protection to the viaduct in the event of an accidental derailment of railway cars passing under the structure. The cast-in-place concrete deck slab carries a two-lane roadway 26-ft. in width. On the east side an 18-in. curb is incorporated into the slab, and a 3-ft. pedestrian walk was constructed on the west side. Aluminium railings were placed on both sides. The use of aluminium for the railings and concrete for all structural members eliminates the necessity for periodic painting and reduces maintenance to a minimum.

The Causeway was designed by, and constructed under the supervision of, Parsons, Brinckerhoff, Quade and Douglas, Consulting Engineers, 165 Broadway, New York. Farnsworth and Chambers Co., Inc. of Houston, Texas constructed the water-crossing substructures, the causeway sections, and the hydraulic embankments. The bascule span was constructed and all superstructure steel was erected by the Kansas City Bridge Co., Inc. of Kansas City, Missouri. The 51st Street Viaduct was constructed by the Texas Gulf Construction Co., Inc. of Galveston.

Development of Port Mwanza, Lake Victoria

New Works Constructed by East African Railways & Harbours

(Specially Contributed)

THE town of Mwanza, together with its port, is situated at the southern end of Lake Victoria and owes its importance in the transport sphere of East Africa to the fact that it is the lake terminal for the railway connecting the inland marine systems of transport on Lake Victoria with the deep-sea port of Dar es Salaam, which is some 765 miles distant by rail. Through the port of Mwanza passes the majority of the produce from the fertile and well populated part of Tanganyika which lies along the western shore of Lake Victoria. The produce, mainly coffee and cotton, is brought across the lake by marine transport and at Mwanza it is transhipped to rail, whence it proceeds by railway to the deep-sea port of Dar es Salaam for shipment overseas. Mwanza is also the capital of the Lake Province which is a very fertile and highly productive area.

In addition to the exports which pass through Mwanza, there is considerable traffic of imports for the west of the lake and it is also the main port for the interchange traffic between Kenya and Uganda and Tanganyika.

The original port of Mwanza is situated to the north of the town and, when it became apparent that, with increase of traffic, expansion of the port facilities was necessary, the question arose whether these should be provided at Mwanza North or an entirely new port be built to the south of the town. Whilst it was possible to expand at the existing site of Mwanza North, other factors entered into the matter, particularly that of town planning. The Town Planning Authority of the Territory, supported by township interests, held the view that the site at Mwanza North was unsuitable in relation to the present general development of the town and the possible future development to expand Mwanza North. A particular point was that it was necessary for the railway line serving the port to traverse a large part of the town with consequently a number of level crossings over important roads. The site at Mwanza South was proposed as being more convenient for rail access, and also as a suitable site in relation to the industrial area of the town. Whilst there were certain difficulties from the Railway point of view, the site at Mwanza South was accepted for cargo working, leaving the main passenger port at Mwanza North.

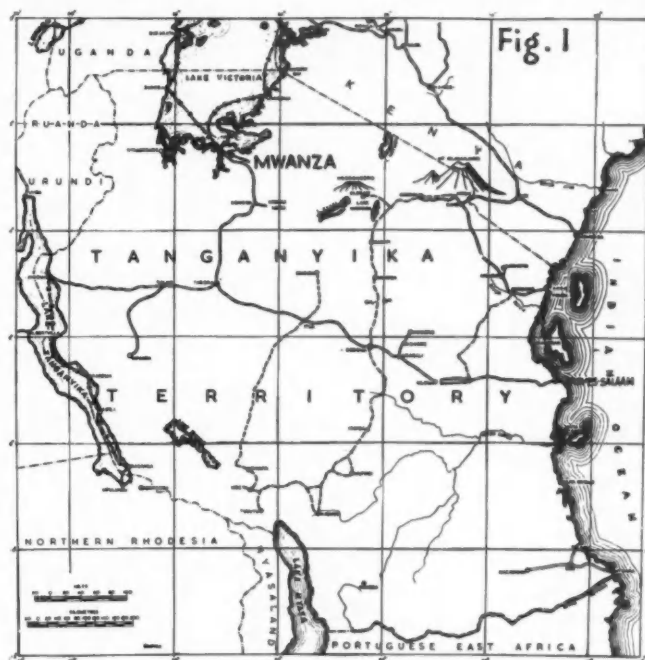
Type of Structure

The investigation of the sub-surface conditions of the site at Mwanza South showed the foundation conditions to consist of a layer of lake silt overlying blue sandy clay, and with stiff yellow clay below this. These conditions indicated a site very suitable for a sheet steel pile wall. This is a type of construction for lake and river piers which has been employed by the East African Railways and Harbours at a number of its lake and river port sites and has proved very successful and economical. It was therefore decided to adopt this method of construction.

Description of Site

The site, as will be seen from Fig. 1, lies between the main railway line from Mwanza to Tabora and the lake shore in a land-locked bay named Capri Bay. It slopes gently to the lake edge, and at the back or landward side of the area the ground rises steeply to the eroded rocky granite hills which are typical of this

part of Tanganyika. The topography of the site, whilst providing advantages for the drainage of rain falling on the site, raised complications of drainage from water arriving on the site from the high ground at the back. This meant not only dealing with a considerable quantity of surface floor water, but necessitated subsoil drainage. The lake shore was covered with a heavy growth of papyrus grass and entangled with the roots of mango



Map showing position of the Port of Mwanza on Lake Victoria.

and palm trees. It proved also to be heavily infested with snakes, and it is pleasant to be able to record that there were no casualties among the labour engaged in clearing the papyrus.

The total area of land occupied by the port is approximately 22 acres, of which about half was reclaimed from the lake behind the wharf walls.

Details of Construction Works

Earthworks

This was the largest section of the work, and it was necessary first to clear the lake shore. It was not possible to get mechanical equipment near the shore line because of the silt, in which plant quickly became bogged down, and the work had therefore to be done by hand. Gangs of labour were put to the task with "pangas," a local East African cutting tool much used by Africans, hacking out the roots and pulling the accumulation of growing vegetation and roots ashore, where it was left to dry and subsequently burnt. Day after day these men, frequently up to their necks in water, hacked and cut a few feet at a time to a daily task set for each gang.

Port Mwanza—continued

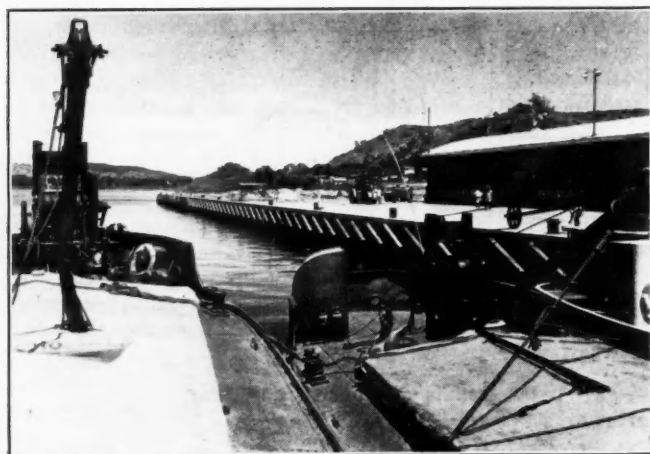
As this work progressed, the bringing in of the earth fill commenced, until it became possible to get tractors into the area, where they were employed on de-rooting and the removal of the heavier tree growth. Grappling irons were manufactured, which proved useful for bringing in the vegetation to the shore line after it had been cut by hand.

The earth fill was transported from the excavation area by train and Euclid lorries. The excavation site for the earth fill



View of wharf face from North end.

was on a hillside, about five acres in extent and was situated some 1½ miles from the work. The material was very suitable, being granular and free from silt. Loading was done by an R.B.19 shovel and later, when this was required for drag-line operation to remove silt, by a 955 Caterpillar Traxcavator shovel. This latter piece of equipment was found to be much quicker for this particular type of loading than the R.B.19. The procedure for placing the fill by train was to lay a track at the back of the area and the earth fill was then off-loaded and spread by dozer. As the work progressed the track was slewed and extended as required so that the fill worked its way up to the original shore line. The Euclids worked from the same quarry as a team, being loaded by 362 Marion Shovels. The combination of train and road transport worked very well. Due to the short haul



View of new wharf nearing completion.

the cost by Euclid was about 13% cheaper than by train. Two shifts were worked of eight hours each for seven days of the week.

The general method adopted in placing the fill as the reclaimed area began to reach out from the existing shore line was designed to avoid pushing silt in front of it into the lake and thereby silting up the proposed wharf front. This was achieved by constructing an earth bund parallel to wharf front and about

60 to 70-ft. inshore from it. This was tipped by Euclids and the object was to trap the silt inshore when it could be removed by drag-line. The bund also provided an excellent jumping-off ground for the construction of the rock bund and retaining wall for the fill. As the work progressed the silt and decayed vegetation was thrown up against the earth bund and a stage was reached when it was necessary to stop bringing in more fill and to employ the Euclids and the R.B.19 and a drag-line to remove the silt. The quantity removed amounted to some 3,700 cu. yds. at a cost of Shs. 5/5 per yard. The silt was deposited at a convenient site to the south of the works on low-lying ground where some 4 acres were reclaimed. Some 169,000 cubic yards of fill was also placed in this reclamation area at a cost of Shs. 4/08 per cubic yard.

Excavation

The excavation at the back of the site proved more difficult than had been expected. Due no doubt to the filling operation described earlier, the natural water seepage into the lake had been interfered with and water came up through the ground at a higher level than the fill which had been placed. Excavation of this saturated ground, which consisted of a black-grey silt, interspersed with white moving sand, proved impossible with dozer equipment and it became a drag-line job. Drainage was put in to lower the water table. Experience during this work indicated that it was not sufficient just to take the excavation down to formation level, but that it was necessary to remove the poor soil for an additional depth of 3-ft. and to backfill with poor quality material, in the knowledge that the drainage would keep the area dry. Conditions were worst at the south end of the port area and at the north end sand was encountered which presented no difficulty in excavation. Some 17,400 cu. yds. were excavated from the back of the site.

Wharf Wall

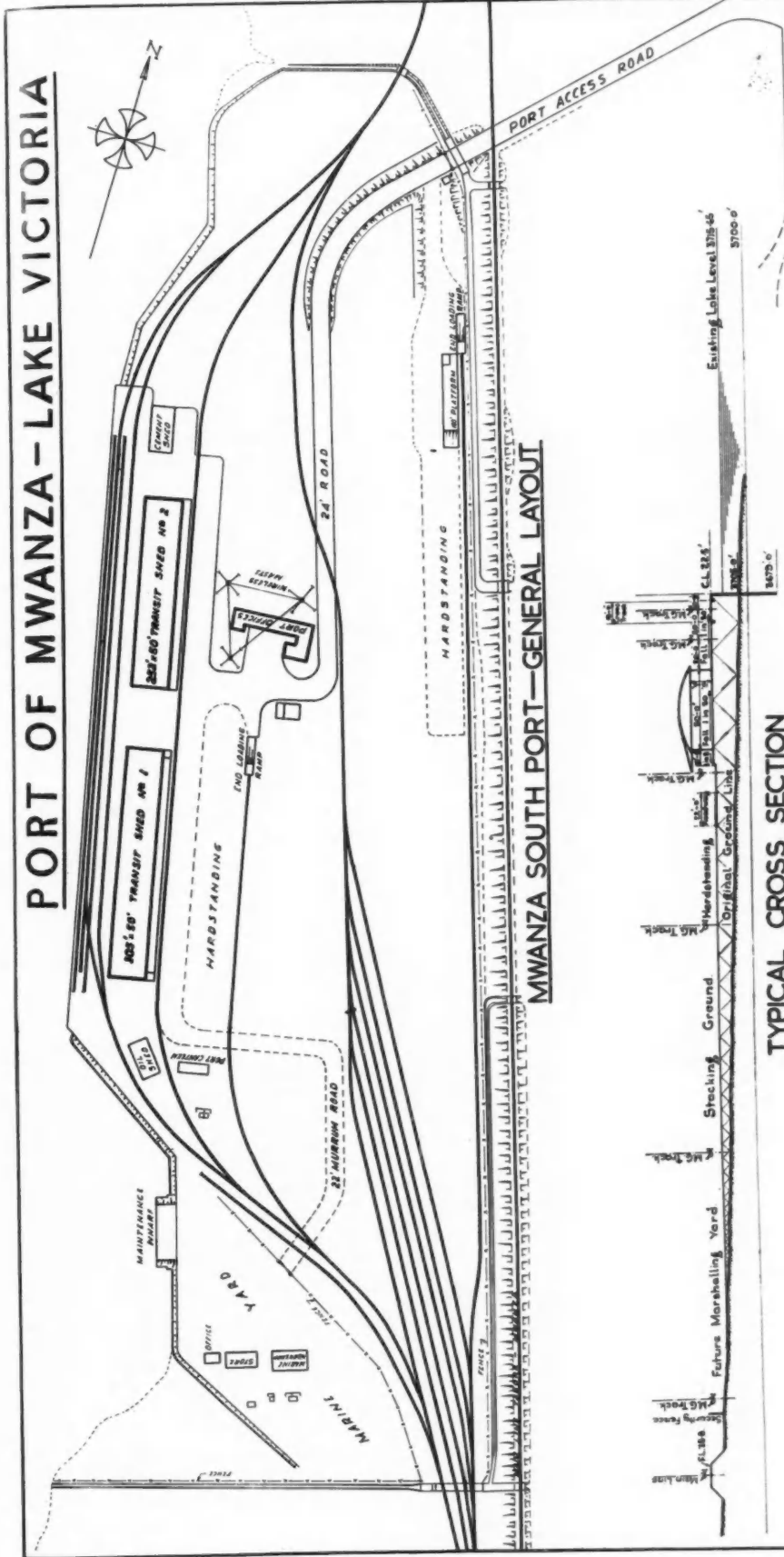
The original scheme was for a sheet steel piled wharf 560-ft. in length, and this was increased to 860-ft. after construction had started. The original length was designed to be built in Frodingham No. II sheet piling which was available in East Africa, and the extension of 300-ft. part in No. III which was also available in East Africa surplus from other work, and part in No. II ordered from overseas. The piles are of 44-ft. nominal length, and were driven by a G.B.3 O/A hammer, from a 45-ft. floating frame.

The piles were driven in just over 10-ft. of water by the normal method using timber guides and walings. They were driven in pairs, being only part driven in the first place, and then subsequently driven to set and cut to level by oxy-acetylene cutter. This method helped to control creep and, in addition, they were prevented from creeping by being tied back by steel ropes and turnbuckles. The subsequent driving was done with a No. 7 S/A hammer.

The sheet piles are anchored back to a reinforced concrete anchor wall with tie-irons, and a concrete cope beam is provided. Bollards are also provided and these are fixed to the sheet steel piling. This work proceeded in the wake of the pile driving. The final alignment of the sheet steel pile face was adjusted within limits of about 2-in. of the tie rods and a very satisfactory result was obtained. The different sections of piling were connected to each other by means of junction piles which were fabricated in the East African Railways and Harbours workshops of the Chief Mechanical Engineer in Nairobi and proved very satisfactory.

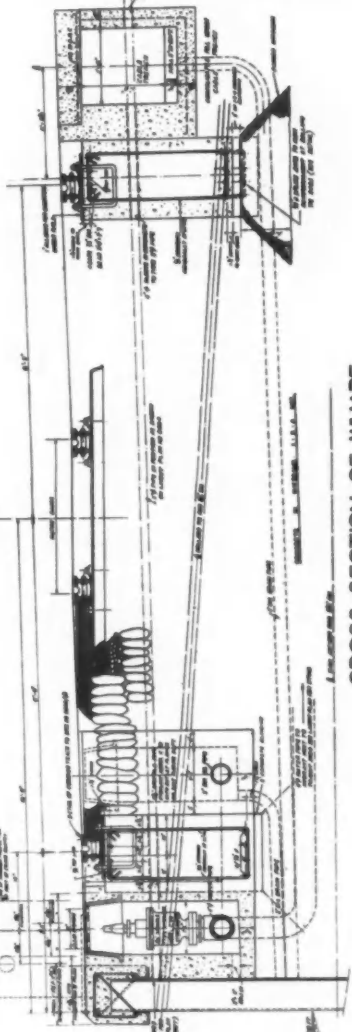
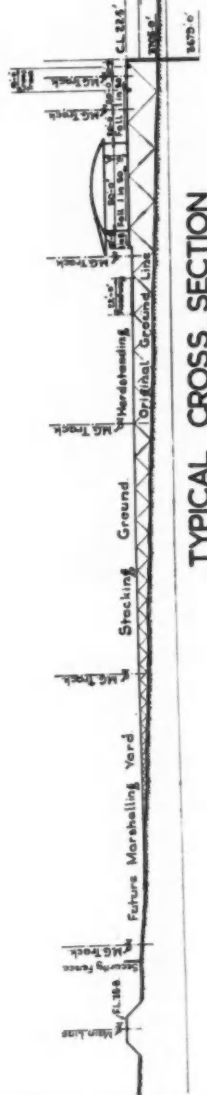
The sheet steel piles were sandblasted and cleaned and painted before driven. Prior to final fixing all steelwork was given a coat of hot 80/100 bitumen and the tie rods were given a hessian wrapping.

PORT OF MWANZA—LAKE VICTORIA

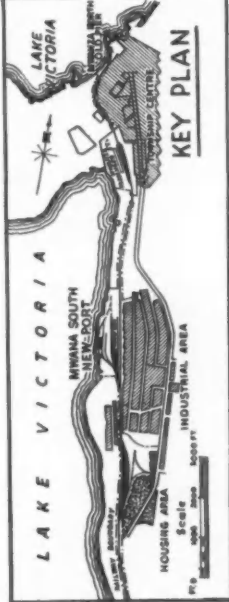


MWANZA SOUTH PORT—GENERAL LAYOUT

TYPICAL CROSS SECTION



CROSS SECTION OF WHARF



KEY PLAN

Port Mwanza—continued

A difficulty arose with the supply of steam to the pile hammer, and this was solved satisfactorily by using a locomotive. Not perhaps a very orthodox procedure, but in the circumstances it proved very effective.

Fendering

The ships on Lake Victoria berth themselves and it has been found that the normal vertical fendering suffers damage from horizontal impact as the ships approach at an acute angle. The system of fendering adopted is to fix the fenders diagonally down the face of the wharf so that there is an overlap of the bottom



Aerial view of the new South Port taken immediately after the opening ceremony on June 4th 1960.



Aerial view of Mwanza North Port.

of one fender with the top of the next. This prevents damage by horizontal impact. The fenders are of timber, Greenheart, which was available from another job, and a local hardwood timber, *Ludulio* (*Manilkara cuneifolia*) which has been used at the Port of Mombasa and up to the present has given good results.

Boulder back fill to sheet steel pile wall and pitching

The sheet steel pile wall is backed with boulders to give support to the wall and also to provide a foundation for the wharf apron and crane rail beams. This rock was quarried from the hills immediately behind the port. The rock is an extremely hard granite and occurs in the form of large boulders rather than a quarry face. Quarrying was commenced using pneumatic drills of the "Silver Bullet" type (Holmans) with drill steels "Avesta" $\frac{7}{8}$ -in. hexagonal with a non-detachable chisel-head tungsten and carbide bit. This equipment had proved satisfactory on hard rocks on other works in East Africa but at the start of the work at Mwanza there was trouble. Drill steels broke and the tungsten

and carbide bits disintegrated and the footage obtained from a drill steel was of the order of 9-ft. to 32-ft. This, besides being expensive, gave an extremely low output of rock. Consultations with Messrs Holman finally resulted in a proposal that the "Silver Three" hammer, a comparatively new arrival in East Africa, should be tried. The primary difference between the "Silver Three" and the "Silver Bullet" is that the former delivers a lighter blow but more rapidly. The use of this hammer solved the problem and footages of 425-ft. to 609-ft. were obtained from a drill steel. The output from the quarry was stepped up from 2,000 cu. ft. per week to 12,000 cu. ft. The rock was transported to the job by tipping lorries and tipped generally in position, the final trimming being done by hand.

The main works other than the wharf wall are two transit sheds, 305-ft. by 50-ft. and 56-ft. respectively and 252-ft. by 50-ft., together with railway sidings and open stacking area of 24,000 sq. ft. The work of the hard standing for the open stacking area, which consisted of a boulder foundation with a bitumen surface, gave some difficulty as the rock was so hard it was difficult to roll the boulder base to a reasonable surface to receive the bitumen finishing coat.

The floors to the sheds are of "Flintkote" laid on a bitumen based surface.

Other buildings provided are the Port Offices, an Oil and Cement Store, an Electrical Sub-station, a Port Canteen and General Store and latrine facilities.

The whole of the work was carried out by direct labour of the Civil Engineering Department of the East African Railways and Harbours under the direction of the Chief Engineer, Mr. C. T. Henfrey.

Food Handling at U.K. Docks

New Hygiene Regulations

New food hygiene regulations affecting the handling of food at docks, carriers' premises, public cold stores and certain types of storage premises have been made jointly by the Minister of Health and the Minister of Agriculture, Fisheries and Food. Most of the provisions will come into force on November 1, except for some which may involve alterations to premises or equipment. These are deferred until May 1, 1961.

The matters dealt with in the new regulations are similar to those that have applied since the end of 1955 to most other types of food premises. There are, however, a number of detailed changes because of the special character of dock premises, carriers' premises, etc., and the operations that take place there. For instance, a great deal of the food is handled in its packing, constant changes occur in the types of food handled, and—in the case of docks—the employer is not normally responsible for providing the buildings or facilities which the dockers have to use in handling food.

The regulations—Food Hygiene (Docks, Carriers etc.) Regulations 1960 have been made under sections 13 and 123 of the Food and Drugs Act 1955. The authorities responsible for their enforcement are borough, urban and rural district councils and port health authorities. The most important differences include the obligations of dockers and porters as to cleanliness of person, clothing, etc., which are limited to occasions when they are handling food which is not packed in such a way as to prevent the food from coming into contact with any surface that the package may touch. In addition certain requirements relating to structure, washing and sanitary requirements are less stringent, since it is not practicable to treat a dock or freight shed as if it were a food shop or factory, particularly as a great deal of the food is handled in its packing.

Book Reviews

Brown's Nautical Almanac, 1961. Published by Brown, Son and Ferguson, Ltd., 52-58 Darnley Street, Glasgow. Price £1 net.

This well-known reference book is now in its 84th year. While it is valuable for its tide tables alone, these constitute only one section among seven others. Hourly astronomical elements of sun, moon and planets are arranged as required by navigators, together with increments and corrections tables. The book also contains speed and distance tables, and a guide to the lights, beacons and buoys of the British Isles. A miscellaneous section takes in diverse information, including tables on breaking stresses and stowage factors, important statutory notes and marine meteorology etc. The book comprises 1,000 pages.

The Strength Properties of Timber (Forest Products Research Bulletin No. 45). Published for D.S.I.R. by H.M.S.O. Price 3s. 6d. (63 Cents, U.S.A.) by post 3s. 10d.

Timber, like all other construction materials, has the ability to resist applied or external forces. This resistance, or strength, involves a number of specific mechanical properties and it is largely these that determine the suitability of a species for a particular purpose. A basic knowledge of the strength properties of a species of timber is therefore essential if it is to be used in an economical and efficient manner. Such knowledge is acquired chiefly from laboratory tests, carried out under controlled conditions on small specimens of timber of regular grain and free from defects.

Bulletin No. 45 which has just been published describes the procedure and methods of tests on 2-in. and 2-cm. specimens, the internationally accepted standards. These were formerly published in Bulletins 28 and 34, which are now superseded. More extensive routine testing has provided additional data for a number of species, and the present Bulletin gives up-to-date information on the physical and mechanical properties of 172 home-grown and imported hardwoods and softwoods.

Ports of the World, 14th Edition, 1960. Published by The Shipping World Ltd., 1 Arundel Street, London. 1843 pp. Price £4 net, plus 3s. post and packing.

With this fourteenth edition the gradual expansion of the volume which has gone on steadily over the years has once more been unavoidable. Despite various measures to rationalise the presentation of port facilities and charges, and despite the exclusion of some of the smaller United Kingdom ports no longer of commercial significance, the number of pages has increased.

Part of this increase is due to the reinclusion of a section devoted to the U.S.S.R. which has been omitted for a number of years as reliable information was unobtainable. However, it has now been found possible to give a full account of standard charges applicable at Russian ports, and the Editor hopes that the brief details of facilities at some of the individual ports may be extended in later editions.

Other improvements and additions include a new and more readable index covering every port entry and cross-reference in the book, extension of the tabular presentation of dues and charges to facilitate easy reference, and a number of revisions and additions to port plans. There are more than 70 new port entries and a further 100 have been completely redrafted. New introductory sections dealing with national conditions and charges are included in the case of 20 countries—in most cases affecting the scale of charges applicable at all the ports of those countries. An additional 130-odd port entries incorporate substantial alterations in charges, while many more include minor amendments to charges and significant alterations in depths in harbour or alongside, quay facilities and so on.

Hydraulic Research in the United States, edited by Helen K. Middleton, National Bureau of Standards Miscellaneous Publication 231, 190 pages, \$1.00. Obtainable from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

This publication, the latest in a series of annual publications dating back to 1951, contains reports on hydraulic research conducted during the past year by various hydraulic and hydrologic laboratories in the United States and Canada. It serves as a guide in the co-ordination and planning of hydraulics research in these countries and thus helps to avoid duplication of research. Project reports include work done at 72 private or State laboratories in the United States, 22 Federal laboratories, and 8 Canadian laboratories, and nearly 200 subjects are covered, describing the nature of the work, a brief description of the progress, the present status and results of the work, and any publications issued. Each report bears an identifying number which it carries from issue to issue, as long as the study is active. In this way, the complete history of any project can be traced from inception to conclusion. Full addresses of all the co-operating laboratories are given, so that detailed information can be obtained from the respective sources.

"Subsunk" The Story of Submarine Escape, by Captain W. O. Shelford, R.N. (Retd.) F.R.S.A., 248 pages 23 illustrations, 12 diagrams. Published by George G. Harrap and Co. Ltd., 182 High Holborn, London. Price 18s. net.

Although many books have been written on individual escapes from a sunken submarine, no writer before has dealt with the subject in general. In this book, Captain Shelford tells the story of the successful escapes from submarines from 1851 to the present day. He has collected the records of these from twenty-two navies of the world and uses them to illustrate the steps taken towards developing efficient means of escape and the different lines of thought followed by the various nations. A number of countries, for instance, long considered that any rescue attempts should be made from the surface by salvage vessels, in spite of the fact that there were many disadvantages. The salvage of a submarine can very rarely be effected in time to save life, and therefore, submarine crews must be prepared to abandon ship on the bottom and save themselves by means of apparatus. Even then they will almost certainly die of exposure unless a search and rescue organisation can be rapidly mounted. Hence, the formation of "Operation Subsunk."

In the second half of the book, the author tells of his own part in the escape story, which began in 1941 when he took over the Submarine Escape Training Organisation in H.M.S. Dolphin at Gosport. After the war, he initiated a programme of escape experiments and served on the Ruck Keene Submarine Committee of 1946. In the final chapters, he points out that the future is by no means easy to forecast. The American nuclear submarines are equipped to take the McCann Rescue Bell and with Momsen Lungs for individual escape; the British "Dreadnought" will be supplied with one-man escape chambers fitted externally to the pressure hull. These devices may give a slender chance of escape from depths below 300-ft., although it is not known at present how deep is the limit for free ascent through a chamber specifically designed to reduce the time under pressure to the absolute minimum.

In a foreword to the book, Rear-Admiral Bertram W. Taylor, D.S.C. points out that every submarine accident is different and that no matter what ingenuity has been used in devising escape gear and methods, the perfect answer has yet to be achieved. "On so many occasions," he comments "the right answer to one problem has been found to be quite the wrong answer to another." Captain Shelford emphasises this point throughout an absorbing book which can be unreservedly recommended.

New No. 5 Dry Dock at Birkenhead

Reconstruction Scheme Nearing Completion

Cammell Laird's new Birkenhead dry dock will have an overall length of 950-ft., a width of 147-ft., and a depth below quay level of 53-ft., the depth of water over the sill being 33.7-ft. at M.H.W.S.T. These dimensions may be compared with other similar large dry docks, as for example, the Captain Cook Dock at Sydney, which is 1,177-ft. long, 152-ft. wide and 50-ft. deep and the Sturrock Dock at Capetown which is 1,181-ft. long, 148-ft. wide and 46-ft. deep. The consulting engineers for this project, Messrs. Rendel, Palmer and Tritton, have designed a curved sill and gate, which is the first of its kind in the United Kingdom, and which will be housed in a camber or recess located in the North wall of the dock. Work was started on the site in August 1958 and forms part of a £17m. reconstruction scheme at the Birkenhead shipbuilding and repair yards. The completion date is April 1961.

Need for Flexible Programme

The bulk of the excavations for the dock required the removal of 400,000 cu. yds. of red Bunter sandstone. The method employed consisted of opening a series of 10-ft. deep trenches across the width of the dock with Consolidated pneumatic type 32 rock drills, using Seco steels to drill 1½-in. dia. holes of 11-ft. depth. The explosive used was 1½-in. polar ammon gelnite. After blasting, excavation proceeded with two 37 RB's and one 38 RB loading to Leyland 10-ton Hippos. The spoil was used to reclaim land for Cammell Laird on their South yard, to fill the inner basin and also to reclaim land for the Mersey Docks and Harbour Board at Dingle. Of prime importance was the need to allow the normal yard work adjacent to the site of the new dock to proceed without interference. Other factors included the necessity of carrying excavations to within 50-ft. of a church; the fact that the site was handed over in twelve areas, as each became available; and the necessity for carrying out surface demolition of quay facilities and buildings, including the felling of a power station chimney and three tower cranes. Thus working methods were kept as flexible as possible and the maximum explosive charge was kept as low as possible. The walls of the excavation are being cut with a modified "Siskol" rock cutter and after excavation will be left to stand without further facing.

A 23-ft. wide rock-filled, double-walled cofferdam 358-ft. long and formed of No. 3 Larssen piling was placed around the entrance of the dock. This was done by excavating a trench in rock with CP.117 paving breakers during two hours each side of low water, the piles being pitched in and concreted in position. An extension along the Southside of the dock is a single-walled cofferdam, the piles here being driven down to hard rock and strutted.

One roundhead at the entrance is being anchored to the rock by prestressed cables using a modified Gifford Udal system.

When the foundations for the buttresses, the sill and the pumphouse were being excavated, inflows of water were encountered and to deal with the resulting grit laden water, two Sykes Univac pumps were employed, one of 6-in. and one of 8-in. capacity with a third 8-in. Univac as a standby. Smaller seepages throughout the excavations are handled by CP.77 sludge pumps.

The sill is of Shap Granite; the face being ground to an egg-shell finish, whilst adjoining surfaces are "fair picked." The dressing required immediately prior to emplacement is being carried out with Consolidated pneumatic type 407 triple scaling hammers. The gatehouse or camber will be provided with a roof, employing precast prestressed concrete beams.

The pumphouse and electrical rooms measures 120-ft. by 50-ft., the excavations being taken down to 24-ft. below datum or 67-ft. below quay level. The main pumps to be accommodated are two 60/54-in. dia. Drysdale centrifugal units, together with a number of ancillary bilge drainage and seepage pumps. An intake culvert 84-in. square and a discharge culvert 60-in. dia. common to both main pumps will be employed. The dock floor is of reinforced concrete 6-in. thick and adjustable bilge blocks will be employed, allowing the walls to be vertical and to contain service galleries.

As will be observed, a substantial use is made of compressed air at the site to operate such power tools as drills, breakers, picks, scaling hammers, saws, grinders, sanding machines, back-fill rammers, poker vibrators and sump pumps. The air for these tools is derived from a ring main fed by four stationary compressors with a total capacity of some 1,700 c.f.m. at 100 p.s.i. two of these units being long stroke, slow speed horizontal machines. Two portable compressors are also operated as the need arises at points remote from the ring main.

Some 48,000 cu. yds. of concrete will have been used by the time the dock is completed. This is mixed in a central Winget weigh-batching plant of 1 cu. yd. capacity, the aggregate being



Checking the alignment of the Shap granite sill.

taken from their respective stockpiles by underground conveyor to the batcher. The control of discharge from the stockpiles to the conveyor and the operation of the conveyor is carried out by one man at a remote control panel, using compressed air controls. Cement is received in bulk from the Tunnel Portland Cement Company, whilst aggregates are derived from deposits at Cefn-y-Bed near Wrexham. A number of classes of concrete are employed according to the duty required. An aspect of the concrete work is the high standard of finish being achieved using standard 8-ft. by 4-ft. forms with plywood linings together with larger R.M.D. units of up to 30-ft. in length and 10-ft. in height. The placing of the concrete, at the entrance is carried out with a Lima 802 crane and vibration is effected with Consolidated pneumatic type 325 poker vibrators with similar smaller units of down to 1½-in. dia. being used where substantial reinforcing occurs.

The main contractors are Messrs. A. Monk and Co. Ltd. Principal subcontractors for the caisson and gate haulage gear are Sir William Arrol and Co. Ltd., and for the pumping machinery are Drysdale and Company Limited.

Manufacturers' Announcements

Hose Handling Equipment for Tanker Discharge

The Globe Pneumatic Engineering Co. Ltd., Romford, Essex, in co-operation with Vilain Freres of Martigues, France, have designed a hose handling installation operated by compressed air which ensures that the complete structure is flameproof. Manipulation of the hoses is by winches fitted at the top of the structure and these are controlled from a main position which provides maximum visibility for the operator.

Once the hoses are connected to the tanker manifold the winches are declutched and the pipes are then supported entirely by counter-weights. During the lowering or discharging operations the hoses follow the movements of the vessel and no additional load is transmitted to the valve flanges. The variable speed of the hoist and winch units allows accurate alignment of the hose flanges during the connection periods, and as the rig is entirely self-compensating under all conditions, it is unnecessary for an operator to remain on duty.

All the machines are totally enclosed and suitable for continuous work in exposed positions.



One of three "Babcock" Selectable-superheat marine boilers, each weighing over 60 tons, being lowered for installation in the hull of the 20,000-ton Portuguese liner "Principe Perfeito" now under construction in the Neptune Works of Swan, Hunter and Wigham Richardson Limited, Newcastle-upon-Tyne. The boiler was manufactured by Babcock and Wilcox Limited and was handled by two "Babcock" 40-ton capacity level-luffing travelling jib cranes working in tandem.

Combating Corrosion

The waste and consequent expense of replacing iron and steelwork which has corroded is tremendous. Expandite Ltd., of Chase Road, London, have spent many years on research into this problem and have produced products aimed to do three things: (1) to prevent rust occurring; (2) to check rust when it has attacked; (3) to provide a decorative finish for the treated surface.

Metagalv is a mainly zinc coating, applied by brush, which gives protection comparable to hot-dip galvanizing, the dried film providing excellent cathodic protection. It contains an exceptionally efficient agent which maintains a good distribution of the zinc particles in the plasticizer and binder, thus enabling a homogeneous mixture to be obtained readily on stirring the contents.

Metagalv contains a water-repellent additive to allow it to be applied to damp surfaces. All surfaces, however, should be free from dust, rust and grease to permit electrical contact between the coating and the base metal. It should be applied at a minimum rate of 1 lb. to 32 sq. ft., and where it is used as a self-finish, two coats should be applied.

Expaflex is a chlorinated rubber coating which provides protection against attack from acids or alkalis. It is quick-drying and is water- and weather-resistant. Applied by brush it is flexible, non-inflammable and has a high degree of impermeability. It is suitable for many industrial applications and is available in more than twenty colours and may be applied to metal, concrete, plaster, brickwork and asbestos.

Gewi Tape is invaluable for the protection of iron and steel in industrial, coastal and other atmospheres where corrosive attack is severe. Available in 30-ft. rolls in widths up to 3-ft., it is self-adhering, rot-proof, water-proof, acid vapour-proof, and is made of an impregnated cotton fabric heavily coated with a corrosion-resistant petroleum grease. It is applied cold and is a self-adhering material unaffected by moisture or frost. It will not crack or harden and will accommodate vibration.

Grab Dredgers for South Wales Docks

The British Transport Commission have recently taken delivery of a new diesel single screw twin grab hopper dredger "Rhymney" built by Charles Hill and Sons Ltd., Albion Dockyard, Bristol for use at the South Wales Ports. The vessel is 156-ft. in length b.p. with a moulded breadth of 34-ft., the hopper capacity being 800 cubic yards.

A second diesel grab hopper dredger for the South Wales Ports was launched at the Albion Dockyard on October 4th named "Ely" and she will have twin screws and be equipped with three grabbing cranes. Her dimensions are: length b.p. 214-ft., moulded breadth 44-ft., hopper capacity 1,700 cu. yds.

The main propelling engines for both vessels are four stroke marine type with reverse reduction gear and two auxiliary four stroke diesel engines are fitted, driving generators for working the deck machinery, electric lighting, and hopper operating gear.

The "Rhymney" has two Priestman No. 50 diesel driven grab dredging cranes and the "Ely" will have three similar Priestman Special No. 60 cranes on completion.

Twin Screw Tug for West Africa

A multi-purpose coastal tug, the "Cosray," was delivered last June by James Pollock, Sons and Co. Ltd., for use in the Nigerian contract being undertaken by the Costain-Raymond Escraves Joint Venture. The tug was ordered by the Caribbean Equipment Company and has been designed to undertake several functions in addition to normal towing duties, such as lifting and moving the 2½-ton mooring anchors of a 600 ton submersible crane pontoon, towing that pontoon from position to position along the mole which is being built, going up river to the assistance of any lighters which may get into difficulties, and carrying personnel along the coast or up rivers in a case of emergency.

The vessel has a length overall of 70-ft. 6-in., a moulded breadth of 18-ft. 6-in., a moulded depth of 8-ft. and a maximum draft aft of 6-ft. 9-in.

It has been designed with a special stern to protect the semi-balanced rudder and the propellers from damage by floating logs and debris.

The main engines are twin screw Crossley type ERL six cylinder engines, each developing 300 B.H.P. when running at a speed of 750 r.p.m., and fitted with a 2-1 reduction gear by Modern Wheel Drive. The power developed at the propeller is 550 B.H.P. and this gave a speed of 10.80 knots during trials.

The windlass is a combined electric and hand unit by Thos. Reid and Sons Ltd., of Paisley, designed to lift the 2½-ton mooring anchors through the necessary purchase over the bow of the tug.

Manufacturers' Announcements—continued

Grain Handling Equipment for Hull Docks

British Transport Docks have placed an order with Spencer (Melksham) Ltd. for the supply of two electrically-driven pneumatic grain elevators which are to be installed at No. 3 Quay, King George Dock, Hull. This new equipment, which will replace existing bucket elevators, will be land based on portal structures.

A contract for the civil engineering work, entailed in the extension of the grain silo at the dock, has been placed with Taylor Woodrow Construction Ltd., Southall, Middlesex. These contracts are part of the £4½ mn. improvement scheme for the Dock.

New Marine Paint

While in industrial areas, smoke and chemicals foul the atmosphere, calling for paint with special properties to resist such contamination, so ships at sea and buildings along the seaboard are exposed to salt water and spray in addition to the normal weathering encountered inland.

A new paint, Saga Super Marine Gloss Enamel, manufactured by E. Wood, Ltd., Ware, Herts., is now offered for the decoration and preservation of buildings situated along the coastline. This product incorporates the latest chalk-resisting and light-fast pigments, and its manufacture is backed by many years of extensive research and practical trials at the Company's marine testing stations, and by more than 70 years experience in manufacturing paints for ocean-going vessels of all types and sizes.

This product is claimed to possess excellent properties of durability, abrasion resistance, gloss and colour retention, and weather and light resistance. It is ideal for the internal and external decoration of all types of surfaces, provided that they are suitably prepared and primed with an efficient type of primer appropriate to the nature of the surface.

Exclusively in our Hands for Sale or Charter

Seagoing selfpropelled dieseldriven suctiondredger "EMERGO" suitable for suction from the bottom into barges alongside or from the bottom through a pipeline ashore.

Built 1959, dim: 39.85 x 9.94 x 1.65/1.35 m. draft, length of suction-pipe 28 m., Ø suction/delivery pipe 0.55/0.50 m., prop. machinery 2 M.W.M. dieselengines of 200 H.P. each, sandpump engine 1400 H.P. M.W.M., sandpump Ø 0.55 m. Suctionpipe fitted with water-gun for pumping hard sand and similar material Ø 0.30 m. driven by 115 H.P. Deutz diesel. Fitted with 18 tons lifting cap. travelling crane elec. driven, diving installation.

For plan, further particulars, please apply to

Scheepsmakelaarskantoor J. Verheul, Scheepmakershaven 53, Rotterdam — telex 21402 — phones 134735 — grams Jeverheul.

CLASSIFIED ADVERTISEMENTS

Rates 4s. per line (minimum 8s.); Box Number 2s. extra; Rate for single column inch is £2 per inch. Prepayment of classified advertisements is requested. Orders should be sent to Advertisement Department, "The Dock and Harbour Authority," 19, Harcourt Street, London, W.1. Telephone: PAD 0077.

WANTED

WANTED: 2/6,000 lb. Forklift Truck, Diesel, Petrol or Electric. Box No. 237, "The Dock and Harbour Authority," 19 Harcourt Street, London, W.1.

FOR SALE OR HIRE

FOR HIRE AND SALE Forklift Trucks of every description including Electric Reach Trucks, Side lift, all tonnage, powered by Diesel, Electric, L.P. Gas, and Petrol. B.G. Plant (Sales Agency), Ltd., Watlington 44, Oxon.

APPOINTMENT VACANT

BRITISH TRANSPORT DOCKS

ENGINEERING ASSISTANT required for work at Southampton Docks at a starting salary of £990 per annum to a maximum of £1,034 per annum. Contributory Superannuation scheme and certain rail travel facilities. Applicants should preferably have had experience in the design of dock-side or similar structures and buildings in steel and/or plain and reinforced concrete. Applications, stating age, qualifications etc., should be addressed to the Chief Docks Engineer, British Transport Commission, Herbert Walker Avenue, New Docks, Southampton.

TENDERS

BOARD OF MANAGEMENT FOR THE PORT OF RANGOON DEVELOPMENT OF THE PORT OF RANGOON SULE PAGODA WHARVES Nos. 5, 6 and 7

CONTRACT No. 3 WHARF CRANES

TENDERS FOR THE SUPPLY, DELIVERY AND SUPERVISION OF ERECTION IN THE PORT OF RANGOON OF SIX 3-TON ELECTRIC LEVEL-LUFFING PORTAL CRANES

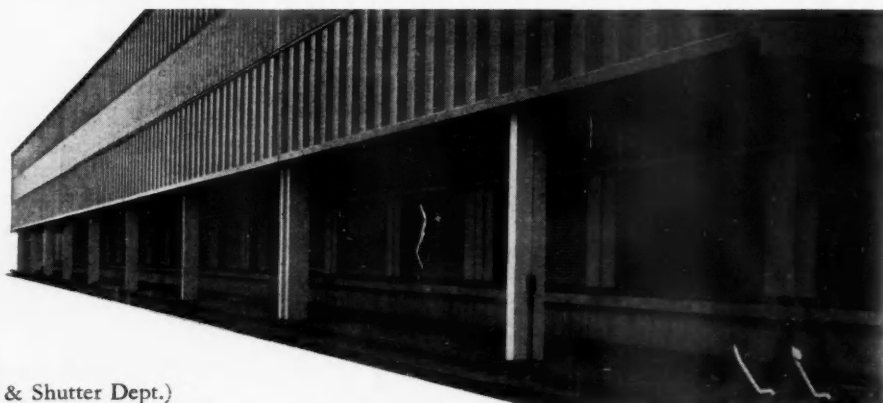
- (1) The Board of Management for the Port of Rangoon invite crane building firms to tender for the supply, delivery, and supervision of erection in Rangoon of Six 3-ton Electric Level-Luffing Portal Cranes for operation on their Sule Pagoda Wharves Nos. 5, 6, and 7.
- (2) Tender Documents consisting of Instructions to Tenderers, Form of Tender, Agreement, Board's Conditions of Contract, Specification and Schedules may be obtained from the office of the undersigned on payment of K.100 per set or from Sir Alexander Gibb & Partners, Consulting Engineers, Queen Anne's Lodge, Westminster, London, S.W.1 on payment of £8 per set.
- (3) Tenders in duplicate must be submitted in sealed envelopes addressed to: The Chairman, Board of Management for the Port of Rangoon, Post Box No. 1, Rangoon, Burma, and marked "Tender for Wharf Cranes." Tenders must reach the above office not later than 12 noon on 7th January, 1961 or be posted to the above mentioned address sufficiently early to arrive on or before the appointed time and date.
- (4) The Board does not bind itself to accept the lowest priced or any tender or to assign any reasons for rejection of any tender.

WIN PE, COMMISSIONER

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